POWER PLANT ENGINEERING

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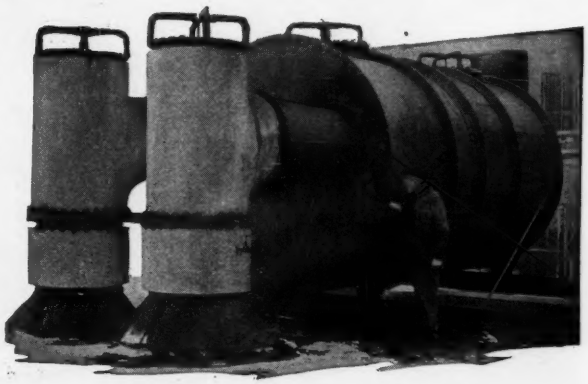


Not a Cough in a Carload

WERE YOU EVER in a "sleeper" and were not a sleeper? The answer is "yes." Was there a cough in that carload? Same answer. Other disturbing evidences of human presence such as cartoonists represent by a cross-cut saw or by the symbol Z-Z-Z-Z were also present no doubt. And what wouldn't you have given for a silencer on those fellow beings. Not so easy.

Shown above is one example of a quieting device, a carload of silencer. Just as a free tip to the Pullman Co., why not install one on each of their cars and connect each alleged sleeper, on request of the other passengers, to it?

Loud coughing and heavy breathing machines, such as oil engines and air compressors, have a persistent way of making their presence known when active instead of when sleeping and of becoming quite a nuisance at times if unrestrained. But a means has been devised to quiet them by choking off the noise of coughing and stertorous breathing of audible machines.

Strange as it may seem at first, interference has a quieting influence in this case, for it is by the breaking up and interference of the sound waves that noise is eliminated.

Silencers of the type shown make possible the location of Diesel power plants in the heart of residential districts where noise would not be tolerated. They are made in sizes much smaller than that shown above, of course, for use in plants such as the Diesel engine power plants at Sibley, Ia., and Walthill, Neb., which are described elsewhere in this issue.

PARIS! CITY OF ROMANCE, of beautiful, wide boulevards, of smartly-dressed women, of the Cathedral of Notre Dame, of the Latin Quarter with long-haired artists and ravishing models! Underneath all this, however, is the work-a-day world of the average Parisian and much of this work depends on electric power, just as it does in this country. If you don't think they have real power plants in Paris, turn to page 920 and read about the Gennevilliers station. You'll be surprised!

Vashon School in St. Louis Makes Own Power

HEATING AND VENTILATING COSTS PER PUPIL AVERAGE ABOUT $0.37 PER YEAR.
HUMIDITY CONTROL, RECIRCULATION, AIR WASHERS AND OZONE APPARATUS PROVIDED

ONE OF THE MOST important fields of engineering, from a public health standpoint of the growing generation, is the proper design and operation of the heating and ventilating systems of school buildings. Naturally, such an important problem, complicated as it is by geographical and climatic conditions, has not been standardized and considerable differences are apparent in various cities.

Of these many cities, the public school system in St. Louis is considered to be one of the outstanding leaders. In general, they favor high pressure boilers, generation of their own electric power, air washing and recirculation. Operating many types of schools, from the oldest to the most modern, they have an unusual opportunity to determine not only the cost but the health standards of the various systems. Briefly the results of such a comparison are shown in Fig. 1 which gives not only the average pupil cost for heating and ventilating per year, in shaded lines, but the average

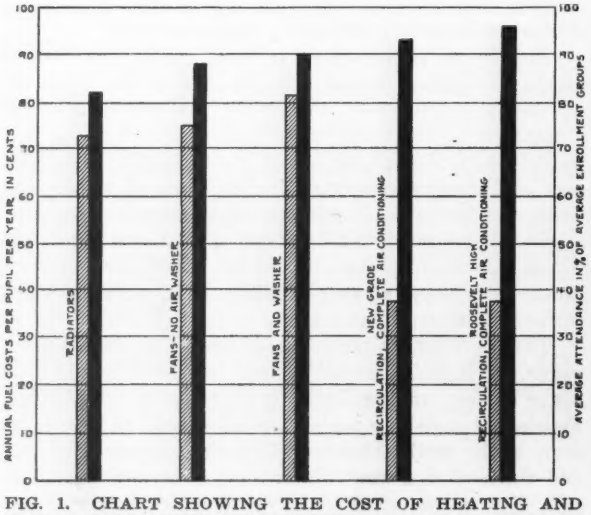


FIG. 1. CHART SHOWING THE COST OF HEATING AND VENTILATING WITH DIFFERENT SYSTEMS IN USE IN THE ST. LOUIS SCHOOLS

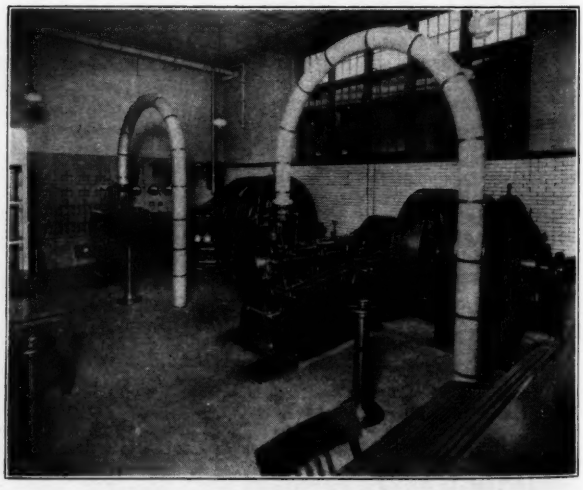


FIG. 2. TWO FOUR-VALVE ENGINE-GENERATOR SETS FURNISH ELECTRIC POWER FOR THE SCHOOL

attendance in per cent of average enrollment for the various groups in solid black.

Plain direct radiation costs $0.73 per year. If mechanical ventilation is used fans add a cent or two to the operating expense and air washers add another small amount. The increased cost of fans and washers over the old schools is, however, but about 9 cents per year per pupil space. In the newer schools this cost of $0.82 is more than cut in half and humidity control, air washers and ozone are all provided at an annual average cost of about $0.37 per pupil.

The Vashon intermediate school for colored pupils with a capacity of 2185 is the latest addition to the school system. The power plant consists of two 300-hp. 175-lb. stoker-fired boilers, a 100-kw. and a 50-kw. engine-generator set, storage batteries, refrigeration system, vacuum sweeping systems and ozone equipment for both air and water purification.

All Power Is Made by Two Engine-Generator Sets

All electric power used for the shops, laboratories, kitchen and general lighting is made in the school. Two four-valve engines, one a 160-hp., 12 by 16-in., 160-lb. steam pressure, 235-r.p.m. engine driving a 100-kw., 250-v. d.c. generator, the other a 240-hp., 14 by 16-in., 160-lb. steam pressure, 235-r.p.m. engine driving a 150-kw., 600-amp., 250-v. d.c. generator are ordinarily used for this service, although a 75-kw. gasoline engine driven generator set is installed for standby, starting or for lighting when the boilers are not operating.

Considerable alternating current is used for the ozone machine, laboratories and small motors. This is supplied by a small 5-kw. rotary converter at 115 v., 60 cycles. Current for the time clock, annunciator bells and 100-tap automatic phone system is supplied by a 36-cell storage battery which is charged through a 300-w. motor generator set, delivering 65 v. d.c. current.

Electrical distribution is taken care of from a six-panel gray marble switchboard, shown in Fig. 5. The control desk, Fig. 6, has all the necessary gages, control buttons and multipoint long distance thermocouples to enable the engineer to maintain the correct temperature in any school room without leaving his station in the engine room.

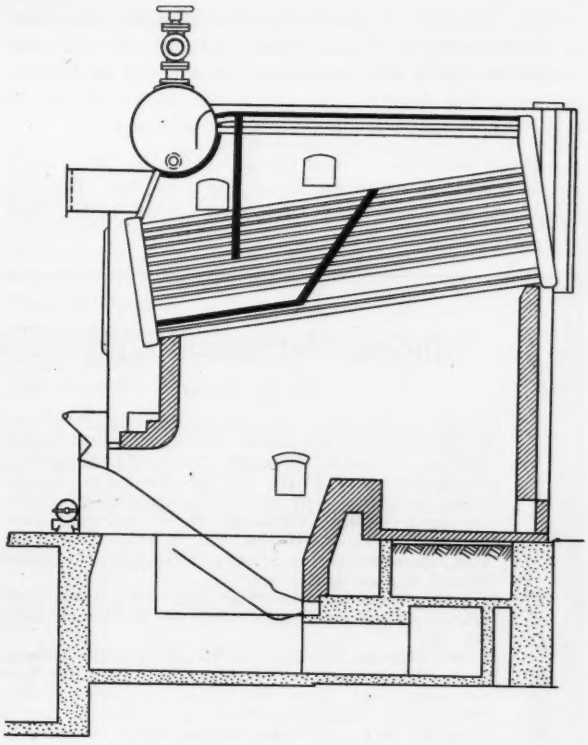


FIG. 4. BOILER CROSS SECTION SHOWING THE SETTING AND BAFFLING ARRANGEMENT

Mechanical ventilation is, of course, used with fresh, washed air entering each room near the ceiling as shown in Fig. 7. It then circles the rooms and leaves through vents near the floor. From the vents in each room, the air rises through spaces between the walls to the attic, where it may be discharged to atmosphere or all or any part of it recirculated through the system again after passing through the ozone machine, air washer and heating coils. Dampers operated from the engine room control the supply of fresh and recirculated air. These dampers are placed close to the fresh air intake located on the roof.

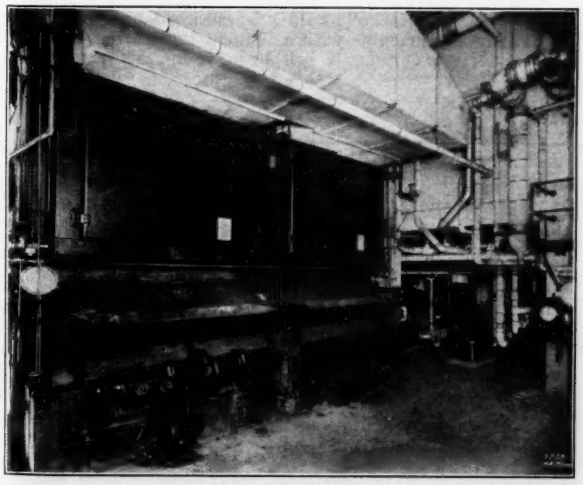


FIG. 3. THE TWO BOILERS ARE EQUIPPED WITH MECHANICAL STOKERS

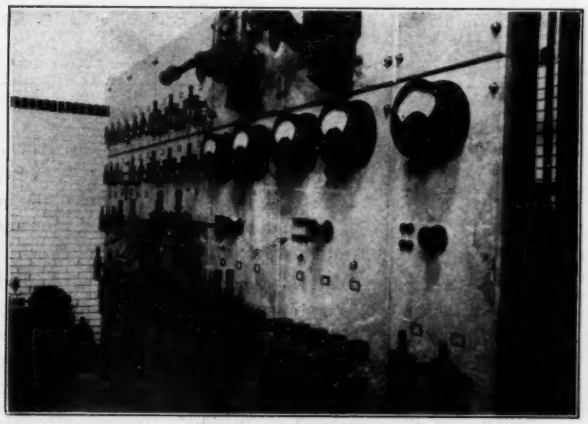


FIG. 5. ELECTRICAL DISTRIBUTION IS HANDLED BY MEANS OF THIS GRAY MARBLE SWITCHBOARD

The efficiency of air distribution through the rooms is illustrated by tests made some time ago. A room was completely filled with smoke and at the end of 5 min., the room was clear to the desk level; at the end of 10 min., it was entirely clear of smoke.

Air to the washers and heating coils can come from any one or any combination of three sources: recirculated exhaust air, fresh air from an intake on the roof for heating but when this supply is insufficient, steam is supplied to the low-pressure system through a reducing valve direct from the boiler.

Coal is brought to the plant by truck and stored adjacent to the boiler room in an underground storage. Firemen wheel it into the boiler room in wheelbarrows as needed and shovel it into the stoker hoppers. All coal used is carefully weighed on platform scales located

Principal Mechanical Equipment at Vashon School, St. Louis, Mo.

Engine Room

1 Elliott Co. 12 by 16-in., 160-hp., 235-r.p.m., 160-lb. steam pressure four-valve non-condensing engine driving a 100-kw., 400-amp., 250-v. d.c. generator.
1 Elliott Co. 14 by 18-in., 240-hp., 235-r.p.m., 160-lb. steam pressure four-valve non-condensing engine driving a 150-kw., 600-amp., 250-v. d.c. generator.
1 Kewanee Private Utilities Co. 75-kw., 125-v., 60-amp., gasoline engine driven, 1150-r.p.m., compound wound, d.c. generator set.
1 Williams Wurbach Electrical Mfg. Co. 6-panel gray marble switchboard installed by E. B. Dorsch Electric Co.
1 Edison Storage Battery Co. 36-cell storage battery.
1 Holzer-Cabot Electric Co. rotary converter for battery charging. Type HC 115-v., 4.5 amp., ½-hp., 1750-r.p.m., compound wound d.c. motor driving a Type HC 65-v., 4.6 amp., 300-w., shunt wound generator.
1 Automatic Electric Co. 100 tap automatic telephone system.
4 Brown Instrument Co. recording thermometers.
1 Brown Instrument 18 point indicating pyrometer.

Boilers and Auxiliaries

2 Heine Boiler Co. 300-hp., 175-lb. gage pressure, horizontal water tube boilers fired by McClave-Brooks Co. stokers.
1 Worthington Pump & Machinery Corp. 10 by 6 by 12-in. simplex steam driven boiler feed pumps.
1 Worthington Pump & Machinery Corp. 4 by 6-in. vertical triplex boiler feed pump driven by 7.5-hp., 250-v. compound wound motor.
1 Simplex Valve & Meter Co. 2.5 in. tube, 1 in. throat, recording feedwater meter calibrated for 200 deg. F. water.
1 Troy Engine & Machine Co. Type SH 5 by 5-in. stoker engine.
1 Cochrane Corp. open feedwater heater.
Steam gages.....Ashton Valve Co.
Water columns.....The Reliance Gauge Column Co.
Soot blowers.....Vulcan Soot Cleaner Co.
Valves and piping.....Crane Co.
Reducing valves.....Boylston Steam Specialty Co.
Back pressure valves.....Cochrane Corp.
Boiler stop valves.....Lunkenheimer Co.
Boiler safety valves.....Ashton Valve Co.

Heating and Ventilating

2 Buffalo Forge Co. size 11 duplex fans each driven by a 20-hp., 230-v., d.c. motor.
2 Carrier Air Conditioning Co. spray type air washer units.
1 Buffalo Steam Pump Co. 5-in., 5-stage, 1750-r.p.m., centrifugal air washer pump with capacity of 750 g.p.m. against a head of 50 ft. Driven by a 15-hp., 2300-v. d.c. motor.
1 Buffalo Forge Co. size 5½ in., exhaust fan driven by a 7.5-hp., 230-v., 690-r.p.m. shunt wound d.c. motor.
1 Dean Bros. 10 by 12 by 12-in. simplex steam driven heating system vacuum pump.
1 American Steam Pump Co. 14 by 12 by 12-in. simplex steam driven air compressor for 100 lb. pressure.
2 Air Conditioning & Engineering Co. ozone machines.
1 Fairbanks, Morse & Co. Fig. 800 ME single stage centrifugal pumps for circulating swimming pool water. Driven by a 7.5-hp., 1750-r.p.m. d.c. motor.
1 American Steam Pump Co. 5 by 6 by 6-in. air compressor for 15 to 17-lb. pressure.
Thermostatic traps.....Warren Webster & Co.

Miscellaneous

1 The Sims Co. size 18 swimming pool water heater.
1 Air Conditioning & Engineering Co. swimming pool ozone machine.
1 Westco Chippewa Pump Co. ice water pump driven by a 1-hp., 230-v., 1750-r.p.m. d.c. motor.
2 Spencer Turbine Co. vacuum cleaners, each driven by a 15-hp., 750-r.p.m. d.c. motor.
1 Peerless Electric Co. 5-kw. rotary converter driven by 230-v., d. c. and generating 115-v., 60-cycle a. c. current for use in the ozone machine and in the physics laboratories.
1 Brunswick-Kroeschell Co. 2¾ by 10-in., 5-t. CO_2 refrigerating machine with a Nugent lubricating system, driven through a belt by a 15-hp., 850-r.p.m., d.c. motor.

or fresh air drawn into a preheater around the stack. All of this air then passes through the spray washer, the ozone chamber, one of the two fans and then through 11,400 sq. ft. of heating coils to the plenum chamber for distribution to the various rooms.

Automatic thermometers placed in the northeast and northwest second floor rooms, which are the coolest in the building, control the general temperature in the plenum chamber system. Individual room requirements are taken care of by regulators or individual dampers.

Steam for all purposes is supplied by two 300-hp., 175-lb. gage, stoker fired boilers. When available, exhaust steam from the engines and auxiliaries is used at the entrance of the boiler room. Ash is stored in the basement temporarily and periodically elevated by a bucket elevator to the surface to be carted away in a truck.

Feedwater is heated in an open feedwater heater, supplied with steam from the low-pressure line. Two boiler feed pumps, one a 10 by 6 by 12 direct acting simplex steam pump, the other a 4 by 6 motor driven triplex are installed so as to give some control of the exhaust steam for heat balance purposes. The water is metered by a feedwater meter calibrated for 200 deg. F. water. The boilers are equipped with recording CO_2 meters.

The stack is a special bell and socket cast-iron pipe, around which is built a brick wall or stack. This brick wall is anchored to the iron stack by special anchors so that considerable air space is left between the two. Cold air enters the intake near the base, passes up on one side and down the other side of the stack, finally passing to the air washers and ozone machines.

Ozone is used for purification and deodorization of both air and water. These machines can be controlled by the engineer. The ozone generated is, of course, a

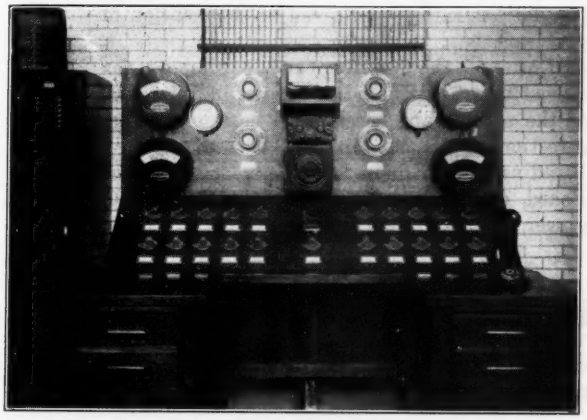


FIG. 6. FROM THIS DESK THE ENGINEER CAN CONTROL THE TEMPERATURES OF VARIOUS SECTIONS OF THE BUILDING

function of the amperage. The variation of ozone concentration for 70,000 c.f.m. of air varies from 0.003 at 6 amp. to 0.02 at 15 amp. The machine for this service is shown in Fig. 8. Ozone is also used for purification of the swimming pool water, the machine for this service differing somewhat in design and is shown in Fig. 8. Swimming pool water is circulated continuously, being filtered and then purified in the ozone apparatus. This purification is accomplished by bringing the water and air saturated with ozone in direct contact in the tall mixing chamber. Tests have conclusively proven the value of this apparatus for water purification and other swimming pools in the city schools are being remodeled to use it in preference to the other methods used previously.

Kitchen and Laboratory Refrigeration Load Considerable

Refrigeration requirements for three ice boxes in the cafeteria and for cooling drinking water is taken care of by a 5-t. CO_2 ice machine. The kitchen is an important part of the school and forms a considerable portion of the power plant load. Soup and vegetable cookers, ranges, ovens, dish washers, potato peelers, toasters, bread mixers, meat cutters, washing machines, ice cream freezers are part of the equipment involved. The cafeteria is operated for pupils of the school. Portions are served at 5c each and a large variety of food is provided.

The vacuum cleaning system installed consists of two 15-hp. motor-driven units. Compressed air at 100 lb. for the kitchen and laboratory is supplied by a 14 by 12 by 12 simplex steam driven air compressor and air at from 15 to 17 lb. for operation of the thermostats is supplied by a 5 by 6 by 6 steam driven simplex compressor. About 2.5 lb. steam pressure is carried on the heating system. With the exception of

Segregated Costs of the Vashon School

General work	$820,181
Plumbing and sewering	74,125
Heating and ventilating	119,166
Boilers	34,048
Engines and generators	18,414
Vacuum cleaning	11,680
Switchboards	4,148
Refrigerating apparatus	4,486
Electric work	56,460
Total	$1,143,280

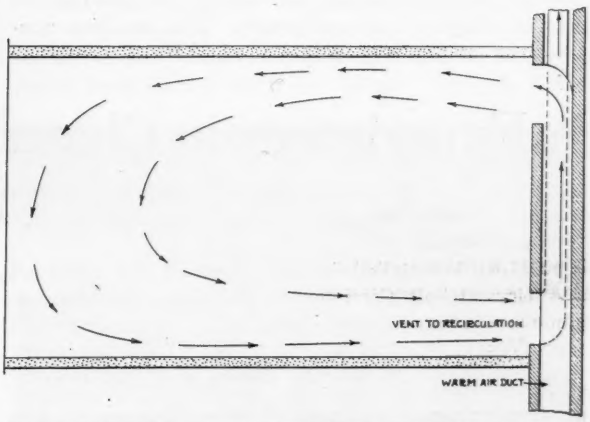


FIG. 7. TYPICAL ROOM ELEVATION SHOWING THE AIR CIRCULATION BY THE ST. LOUIS SYSTEM

the coils near the fans, which drain by gravity, the entire heating system drains back to a 10 by 12 by 12-in. steam driven simplex vacuum pump.

It is sometimes difficult for visiting school officials to understand how a complete heating and ventilating plant with automatic control of temperature and humidity, with air washers for removing dust and ozone machines for purification can be secured at the price

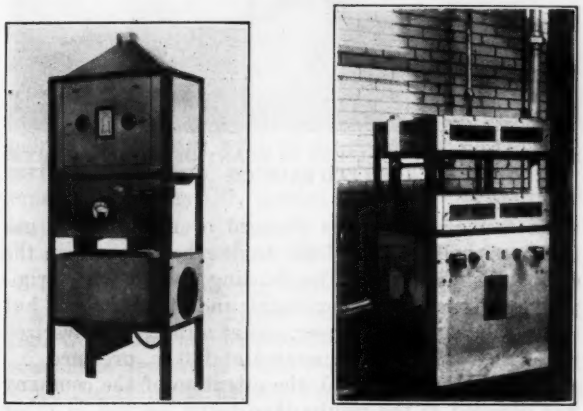


FIG. 8. AIR IS PURIFIED AND DEODORIZED BY THE OZONE MACHINE AT THE LEFT, AND SWIMMING POOL WATER IS PURIFIED BY THE MACHINE SHOWN AT THE RIGHT

of a plain radiator system without ventilation. This is being done over and over again in St. Louis by efficient plant design and operation. The prevailing demand of a St. Louis grade school is from 1200 to 1300 pupils with class rooms, playgrounds, gymnasiums, assembly rooms, community rooms, faculty rooms and the usual offices and storerooms. The volume is about 1,000,000 cu. ft. Heating and ventilating plants for such a building now cost about $38,000 to $40,000. Some years ago, the plant for the same building would have cost $65,000 or $70,000. St. Louis is building not less than three new school buildings a year, and the cost of the complete power plant, with the dual system in several rooms, is reduced to less than 4c per pupil, while the cost of the whole building is about $3 per pupil.

All the criticisms of mechanical ventilation are carefully investigated and can usually be traced to the man in charge of the equipment. This has been remedied by employing operators of above the average intelligence and training them thoroughly by the apprentice system.

In St. Louis, about five years of apprenticeship are required before a man can qualify as head man with sufficient experience and training to handle such a school. Furthermore the training does not stop there and a school for custodians has been in operation in St. Louis for more than 8 yr. Custodians meet regularly for specific instruction in the operation and maintenance of the plant. Not only are lectures given upon every phase of management of the school properties, but demonstrations are given of the solution of difficult problems.

Costs of the building and equipment for Vashon School were distributed as shown in the table. Design of the schools and mechanical equipment is under the direction of R. M. Milligan, Commissioner of School Buildings, and Edwin S. Hallett, Chief Engineer of the Board of Education. Alex. Robertson is Chief Engineer of the Vashon School.

Experiences in Changing to Pulverized Coal

CHANGING FROM STOKERS TO PULVERIZED COAL EQUIPMENT NECESSITATED SOME EXPERIMENTING AT DIAMOND CRYSTAL SALT CO. PLANT. BY M. J. GEARING*

BOILERS installed in the plant of the Diamond Crystal Salt Company at St. Clair, Michigan, include six 333-hp. Wickes vertical water-tube boilers and four 905-hp. Stirling boilers. The Wickes boilers all were equipped with Murphy stokers until just recently

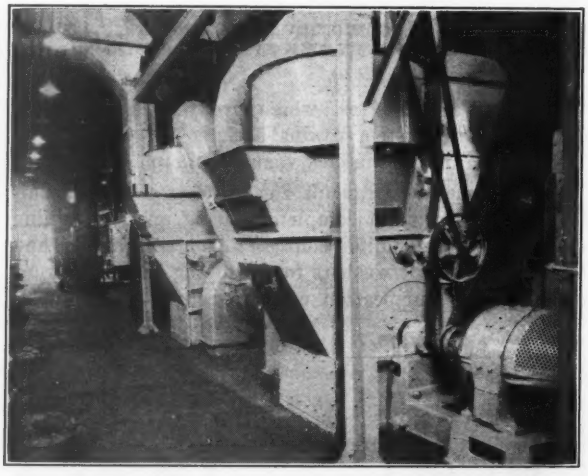


FIG. 1. UNIT PULVERIZERS IN PLANT OF DIAMOND CRYSTAL SALT CO.

when five of them were changed over to natural gas firing, a small supply of gas having been found on the company's property. The Stirling boilers were originally equipped with horizontal underfeed stokers but are now being changed over, one at a time, to pulverized coal firing. Steam is generated at 130 lb. pressure.

During the year 1925, the attention of the company was directed to the results then being secured in other plants with pulverized coal and an investigation was made as to the desirability of equipping its boilers to burn this fuel. An examination of the available operating records of a number of plants using pulverized coal together with inspection of a large number of installations and an analysis of preliminary proposals and guarantees made by several manufacturers of pulverizers led to the conclusion that installation of pulverized coal furnaces under the 905-hp. Stirling boilers would be a profitable investment of high order.

No consideration was given to the installation of pulverized coal equipment under the Wickes boilers because of the fact that they were used but little and also because their settings did not lend themselves readily to the construction of suitable furnaces. The conclusions reached applied only to such an installation as compared to the then existing stoker installation and not to stokers generally. No doubt there are a number of stoker installations where their replacement with pulverized coal equipment could not be justified.

Choice was made of the unit system in preference to the central storage system because of the large extra investment required for the latter, which in this case could not be justified and also because of the large amount of space required for the necessary storage system equipment, which was not available.

As a result of this investigation, which covered a period of nearly a year, it was decided to equip one boiler for the burning of pulverized coal and, in May, 1926, the order was placed for the unit pulverizers.

In order to provide sufficient furnace volume for the maximum loads that it might be desired to carry, the furnace was enlarged by moving the front wall out about 6 ft. and by removing the old stoker wind-boxes and ash hoppers, thus permitting the placing of the furnace floor well below the firing floor. This gave a furnace volume of approximately 5600 cu. ft.

Various types of construction were considered but in view of the existing lack of definite data regarding the

*Engineer, Diamond Crystal Salt Co.

behavior of water-cooled and air-cooled walls in connection with pulverized coal operation and also because it could not be foreseen just what conditions would be encountered in this particular installation, it was decided to proceed with a solid brick construction for this first furnace and to be guided in future installations by the experience obtained under actual operating conditions.

For the initial installation, the pulverizer chosen was the Type 2C Unipulvo, two of which were required, giving a total capacity of 4 t. of coal per hour. This was considerably in excess of the amount which it was expected would be required to develop the maximum load on the boiler, but provided a reasonable leeway or factor of safety for wet coal and permitted normal operation at below rated capacity of the pulverizers. The machines are driven by 60-hp. motors.

Burners originally installed, but which were later replaced by another type, were of the fish-tail or fan-shaped type, being 4 ft. wide and 10 in. deep at the outlet. These, of which there were two, one from each pulverizer fan, were inserted through the front wall about 5 ft. above the furnace floor, the spouts leading from the fans down through the firing floor and gradually increasing in width and decreasing in depth as they approached the burners. Practically all of the air required for combustion was admitted at the pulverizer, none being admitted at the burner.

Coal is fed to the pulverizers from an overhead bunker, first passing through automatic coal scales, so that all coal pulverized is measured.

Correcting Initial Difficulties

This first installation was completed and put in operation in November, 1926. The results obtained were, in general, satisfactory and up to expectations, although there were a few difficulties encountered which required some study and experimenting before they were overcome. The worst fault consisted of uneven distribution from the burners, the bulk of the flame coming from the outer half of each burner, striking first the side wall and then glancing off to strike the bridge wall. Most of the flame was on the side of the furnace, leaving a comparatively quiet zone in the center. Instead of a short flame, evenly distributed across the width of the furnace, there were two separate long flames, one on each side, impinging against the side walls and bridge wall.

Inasmuch as this same type of burner was in successful operation in a number of other installations, it was difficult to understand why they should not be equally successful in this case. Various expedients were tried in an attempt to correct the trouble, such as the placing of deflector plates in the spouts, decreasing the width of the burners and changing the arrangement of the fan blades, but without marked success until an entirely different type of burner and spout were tried which effected a complete cure of the distribution trouble.

This new burner is of the round so-called "whirling burner" type in which the stream of pulverized coal and primary air strike a cone placed in the center of the burner which spreads the stream of coal and air evenly around the periphery of the burner. This cone is equipped with a number of vanes which impart a whirling motion to the stream. Secondary air is drawn by natural draft of about 0.10 in. through a register around the outside of the burner and, as the secondary air meets the whirling circle of primary air and coal, an intense turbulence is set up. It was decided that the uneven distribution at first secured was due largely to the fact that the coal and air separated in the fan, a great deal more coal being on one side of the spout than on the other.

In order to correct this and to insure a homogeneous mixture of pulverized coal and air striking the cone, two changes were made. One of these was changing the arrangement of the fan blades and discharge so as to minimize as much as possible the separating action in the fan. The other change was the placing in the burner spout of a "mixing nozzle" the purpose of which was thoroughly to mix the stream of coal and primary air before it reached the burner.

This "mixing nozzle" consisted simply of a venturi tube-shaped section of spout, the exact dimensions of which for best results were determined by experiment, placed immediately before the burner. The new burners were also placed so as to point slightly toward the center of the furnace and slightly upward. The results obtained with this new burner and spout are a great improvement over those previously secured and are considered quite satisfactory. The flame is short and bright and clear and there is no impingement upon the furnace walls or boiler tubes, nor does the flame "scrub" along the side walls. The flames from the two burners meet in the center of the furnace, resulting in intense turbulence and rapid combustion.

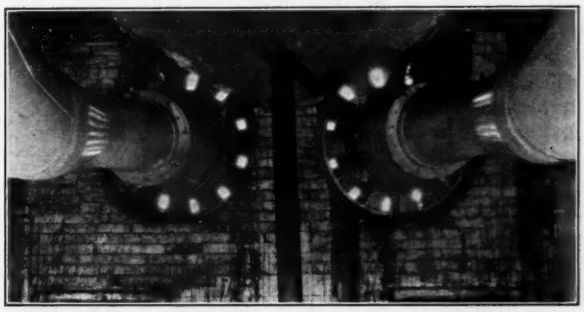


FIG. 2. FURNACE WITH TWO PULVERIZED FUEL BURNERS OF TURBULENT TYPE

Overall boiler efficiencies ranging from 77 per cent at 218 per cent of rating to 80 per cent at 168 per cent of rating were obtained during a series of tests run on this boiler. As previously mentioned, this boiler has a solid brick furnace with no air-cooled or water-cooled surfaces and there is no economizer, air heater nor superheater. The CO_2 carried varied between 14 and 15 per cent.

Slagging at High Ratings

Considerable slagging difficulty is encountered in this furnace at the higher percentages of rating and high CO_2. The ash becomes so "sticky" that it is impossible to remove it while the boiler is in operation. Since the boiler is usually kept in continuous service 24 hr. a day for periods of three or four weeks, the ash tends to build up into a "sticky" mass on the floor of the furnace and upon cooling forms a hard slag which is difficult to remove without damage to the furnace

walls and floor. A small amount of slag also forms on the upper part of the walls and on the boiler tubes which "see" the fire but this has caused no harmful effects.

This slagging is greatly reduced and almost eliminated by holding the boiler load at a maximum of 175 per cent of rating and the CO_2 at 13 per cent. The coal used is a good grade of West Virginia coal, with an average heat value of about 13,500 B.t.u. and a fusing temperature of the ash of about 2500 deg. The daily operating overall boiler efficiency under these conditions averages about 78 per cent.

After six months' operation it was decided that the results being obtained were sufficiently satisfactory to justify a second pulverized coal installation, the only objectionable feature of the first installation being the slagging which, it was believed, would be eliminated by the proper design of furnace walls.

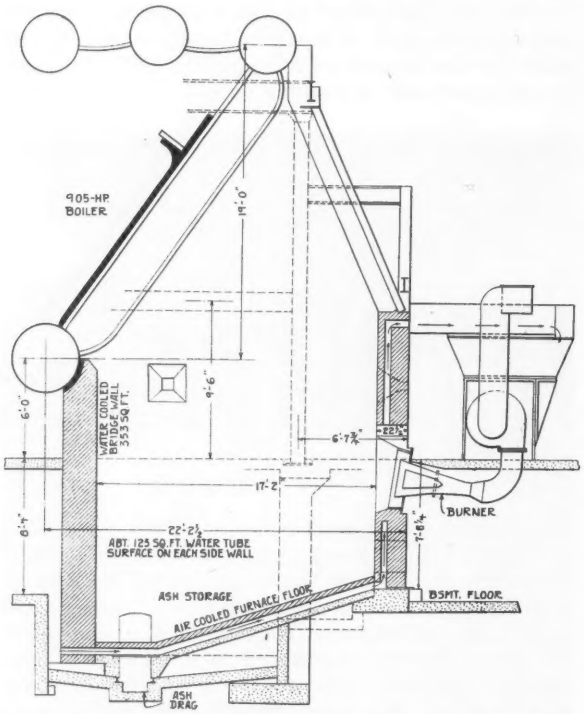


FIG. 3. BURNER PLACED AT ANGLE RETARDS SETTLING OF COAL PARTICLES

This second furnace is equipped with a water-cooled bridge wall and the rear two-thirds of each side wall is also water-cooled. The bridge wall has 353 sq. ft. of exposed tube surface, consisting of 32 bare tubes 3¼ in. diameter spaced at 6 in. centers, and the two side walls have 257 sq. ft. of tube surface, consisting of 22 bare tubes 3¼ in. diameter spaced at 12 in. centers, 11 tubes on each wall. These tubes are connected into the boiler circulation.

Air-cooling is employed for the furnace floor, which slopes upward from rear to front, also for the front portion of each side wall and the front wall. The air enters the air space at the rear of the floor, passes into the front wall and thence upward to a metal duct built around the top of the front wall and is then drawn into the pulverizers by the suction of the pulverizer fan. The side wall air, which enters the air space through thimbles set in the bottom of the walls, reaches the pulverizer in similar fashion. This air attains a temperature of about 210 deg. in passing through the floor and walls, consequently it is of value in drying wet coal and stimulating rapid ignition, as well as in cooling the walls. The volume of this furnace is identical with the other, that is, about 5600 cu. ft. Overall efficiencies obtained on this boiler vary from 77 per cent at 250 per cent of rating to 80 per cent at 200 per cent of rating, a gain of about 2 per cent over those secured with the solid brick furnace at corresponding loads.

Furnace Operation Is Improved by Water Cooling

Water cooling or air cooling of the furnace, particularly the former, is of great value in eliminating slagging and reducing furnace maintenance, while at the same time increasing the boiler efficiency and capacity. While, in this case, the primary object of the water-cooled walls was to secure the former results, the gain in efficiency has in itself been sufficient to warrant the installation. Slagging is practically eliminated, ash removal is greatly facilitated and furnace maintenance apparently is greatly reduced.

After five months of operation at loads between 225 and 250 per cent of rating, with peaks as high as 275 per cent, the furnace walls are apparently as good as when first put in. There is a thin coating of light slag on the side and front walls but no attempt is made to remove this; the bridge wall is practically free of any deposit. The ash is removed once a day while the boiler is in service by means of a compressed air lance by which it is blown out into a conveyor running under the furnace.

As mentioned previously, this cannot be done in the solid brick setting because of the fusing of the ash, as it is necessary to wait until the boiler is taken out of service. About 85 per cent to 90 per cent of the ash passes out with the flue gases, the remainder dropping out in the furnace. The bare tubes of the water walls show no sign of failure or deformation. The cooling effect of the water walls on the furnace temperature is apparent in the slightly darker color of the flame as compared with that in the solid brick furnace, which, as mentioned previously, is clear and transparent.

Water-Cooled Furnace Permits Higher Heat Liberation

In the water-cooled furnace, the flame is also somewhat longer, indicating that more time is required for combustion, but there is no impingement on the bridge wall or tubes and combustion is completed before the gases reach the boiler tubes. The maximum rate of heat liberation in the water-cooled and air-cooled furnace has been about 19,500 B.t.u. per cu. ft. of combustion space per hour with an average for best results of about 16,000. Higher rates may be carried without damage to the furnace but with lowered boiler efficiency. In the solid brick furnace, it has been found best to limit the rate of heat liberation to about 13,500 B.t.u. per cu. ft. for best results.

One advantage of the solid brick furnace over the water-cooled is that it is an easier matter to carry light loads on that boiler, that is, loads below 150 per cent of rating. The chilling effect of the cooled walls tends

to retard ignition so that "puffing" may be caused, particularly if the coal is unusually wet and there is likely to be a loss due to incomplete combustion. On several occasions when the load has been light so that only one pulverizer was in operation, the fire has died out, due to the use of wet coal and chilling effect of the water and air-cooled walls. This is a point that should be borne in mind in the design of such walls. In this connection, the problem is to install sufficient cooling surface to prevent slagging or fusing of the ash and at the same time keep the furnace temperature high enough to prevent losses due to incomplete combustion at any loads the boiler may be called upon to carry. The use of the turbulent short flame burner with which the flame is kept as far as possible from the chilling effect of the walls and of coal of a high degree of fineness makes the solution of this problem somewhat easier.

Burners of Turbulent Type

As mentioned previously, the burners, of which there are two, one from each pulverizer fan, are of the horizontal turbulent type, set in the front wall about 5 ft. above the furnace floor, which slopes away from the wall at an angle of about 17 deg. The burners are pointed slightly toward the center of the furnace and slightly upward. This tends to keep the flame away from the side walls and floor and at the same time increases the turbulence as the flames from the two burners come together in the center of the furnace.

One advantage of this burner arrangement is that the upward flow of the gases tends to retard the dropping out of any coarse particles of coal and so keeps them in suspension longer so that they may be more completely burned. The amount of primary air, which is usually about 80 per cent, is controllable by means of a suitable damper in the fan inlet and the quantity of secondary air which enters around the outside of the burner also may be varied at will.

Ignition takes place at the burner mouth, the flame is turbulent and short and there is no impingement on the walls. By the use of only one burner for each pulverizer, there is no problem of securing even distribution of the coal and air stream among a number of burners, which is frequently a serious matter when the output of one machine is divided among two or more burners.

Fineness of Pulverization

One point on which there seems to be a wide difference of opinion is the necessary degree of fineness for best results. This is influenced largely by the different features of the installation, such as kind, size and shape of the furnace, type of burner and method of firing, kind of coal and other factors. In this particular case, satisfactory results are obtained with coal pulverized so that only 75 per cent passes through a 100 mesh screen, and 1 to ½ per cent remains on a 50 mesh screen.

This is probably somewhat coarser than is generally considered good practice, but it is doubtful that finer coal would give appreciably better results. Such coarse particles as drop out of the flue gases in the furnace are completely burned on the furnace floor, which, as explained above, is but a few feet below the burners. It is difficult to measure the carbon loss up the stack but judging by the color of the smoke leaving the stack and analysis of the flue dust, this loss is not large.

Were a higher rate of heat liberation desired, finer pulverization no doubt would be essential. Finer pulverization requires more power, which is an item to be considered when power costs are high and also causes greatest wear on the pulverizer.

Moisture in Coal

It is possible to pulverize coal which contains a high per cent of moisture, some of the coal which has been successfully handled being so wet that it could be molded into balls in the hand. Coal as wet as this causes feeding difficulty, particularly slack, as it tends to pack in the feeding mechanism of the machine and so restrict the entry of coal into the pulverizing chamber. Once inside the pulverizer, it may readily be pulverized, although certain adjustments are usually necessary.

For instance, an increase in the amount of primary air is of benefit, having an increased drying effect and increasing the velocity through the machine. Preheated air greatly facilitates the handling of wet coal, as is shown in the second installation where it is obtained from the hollow floor and walls. Wet coal tends to decrease the capacity of the pulverizers and also causes an increase in the power consumption per ton.

In the pulverized coal furnace, while the ash from this coal increases the amount of slagging somewhat in the solid brick furnace, no trouble is experienced in burning it efficiently nor is the maximum load which may be carried appreciably reduced. While no extended tests have been made to determine the flexibility of the pulverized coal equipment in respect to various kinds of coal, experience so far would indicate that any of the ordinary grades may be handled satisfactorily.

Maintenance Costs

Up to date, the cost of hammer replacements on the pulverizers has averaged about 1¼ cents per ton of coal pulverized and the cost of all replacements over a long period of time, including crusher and feeder rolls, fan wheels, etc., will average about 2½ cents per ton of coal pulverized.

Furnace maintenance with solid walls is about the same with the stokers and pulverized coal with perhaps a slight difference in favor of the stokers. The reduced furnace maintenance due to the air-cooled and water-cooled walls would, no doubt, also be realized in a stoker furnace so equipped.

Power required for operating the two pulverizers per boiler amounts to about 67 kw. at 200 per cent of boiler rating, or about 22½ kw-hr. per ton of coal pulverized.

Reliability of Installation

These pulverizers have proved fully as reliable as the stokers in freedom from breakdowns and continuity of operation. In this respect, the pulverizers really are superior to the stokers in that the pulverized coal boilers need not be taken out of service to make pulverizer repairs which can be made on one machine at a time with the boiler in operation, although the boiler load, of course, is reduced. The most frequent repair is the changing or turning over of the hammers, which requires about 2 hr. on each machine about once every

month or six weeks. In order to replace stoker parts, excepting, of course, those outside the furnace, it is necessary to take the boiler out of service.

No trouble has been caused by tramp iron, rock or other foreign material getting into the pulverizers. In this installation, no magnetic separator or other separating device is required, the design and construction of the machines being such that material of this nature is either ejected from the machine as it passes into the feeding mechanism, or is deposited, without causing any damage, in a pocket in the bottom from which it is removed when the machine is shut down.

So far, the results obtained in this plant with pulverized coal have been generally satisfactory and the expected savings are being realized. The estimates on the installation showed that a return of 45 per cent on the investment might be expected when the change to pulverized fuel was completed and, while the change is not yet complete, the savings already made indicate that this estimated return will materialize.

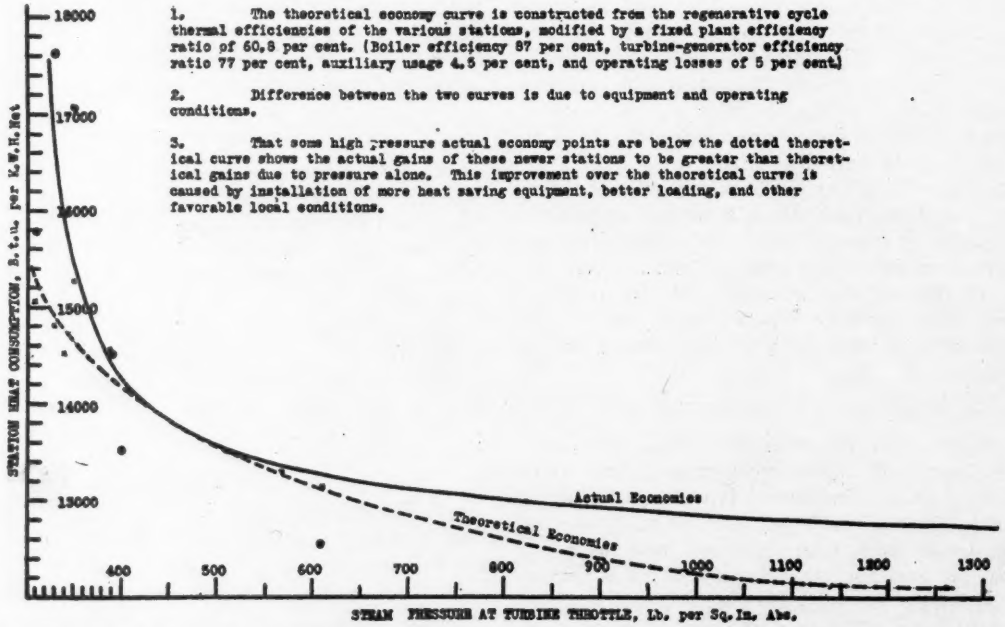
To secure a successful pulverized coal installation, there must be careful combining and balancing of a number of different elements or factors, the more important of which are the pulverizers, spouting, burners, furnace and boiler, each one of which must be properly designed and installed in relation to the others, and to the type of coal to be used. Not one of these can, by itself, bring about satisfactory results if any of the others are not right.

Certain results may be secured in one case with a certain type of pulverizer, or burner, or other factor, but this fact does not insure that exactly similar results will obtain in another case where the same type of equipment is used unless all of the other factors are the same and, even then, it is doubtful that the results will be precisely the same. Slight changes in design or arrangement are likely to produce unexpected results. Each proposed installation is a problem in itself and must be studied and solved as such, if satisfactory performance of the whole is to be secured.

Economies of Higher Pressures Substantiated

HIGH PRESSURES APPEAR TO PLACE NO HANDICAP ON TURBINE EFFICIENCY*

ECONOMY DATA from 10 representative high pressure and temperature power plants has shown a realization of theoretical gains from higher steam pressures and temperatures. Heat consumption rates of these stations, as shown in the table, are supported by detailed data comparing actual with calculated results and are the ultimate proof of the value of extended steam conditions.


1. The theoretical economy curve is constructed from the regenerative cycle thermal efficiencies of the various stations, modified by a fixed plant efficiency ratio of 60.8 per cent. (Boiler efficiency 87 per cent, turbine-generator efficiency ratio 77 per cent, auxiliary usage 4.5 per cent, and operating losses of 5 per cent.)
2. Difference between the two curves is due to equipment and operating conditions.
3. That some high pressure actual economy points are below the dotted theoretical curve shows the actual gains of these newer stations to be greater than theoretical gains due to pressure alone. This improvement over the theoretical curve is caused by installation of more heat saving equipment, better loading, and other favorable local conditions.
STATION HEAT CONSUMPTION, B.t.u. per K.W.H. Net
18000
17000
16000
15000
14000
13000
Actual Economies
Theoretical Economies
400
500
600
700
800
900
1000
1100
1200
1300
STEAM PRESSURE AT TURBINE THROTTLE, Lb. per Sq. In. Abs.

A COMPARISON OF THE ACTUAL AND THEORETICAL ECONOMIES OF VARIOUS PRESSURE STATIONS

Higher pressures do not cause lower turbine efficiency, for one company reports a large reheat condensing machine having an 80.5 per cent efficiency ratio, while another reports a small high pressure unit expanding superheated steam from 1200 to 300 lb. at 80 per cent efficiency. Water rate curves show high pressure machines to have exceedingly flat characteristics, furnishing a reason why the value of high pressure is not confined necessarily to base load plants. Extraction gains are increased by pressure advances.

Records show a steady increase in pressures in central station plants and, though the maximum temperatures have not increased, the average of the recently

*A report of the Prime Movers Committee of the N. E. L. A.

built plants would undoubtedly show a more general adoption of high pressures. A summary showing the effect of higher temperatures and pressures on station thermal efficiency can be stated briefly in seven paragraphs.

1. Though individual station economy is not an exact function of steam pressure, a definite trend toward lower heat consumption is shown by the higher pressure stations. The curve reproduced shows a comparison of the theoretical and actual economies as a function of the steam pressure.

2. In the three highest pressure stations a combination of pressure and reheat effects an important gain.

Loss due to non-use of reheat is shown by the energy balance of the 570-140 lb. station to be 2.4 per cent increase in heat consumption due to operating 16 per cent of the total turbine hours without reheat. Operating the total time without reheat would thus increase the heat consumption 16 per cent. The importance of continuous use of reheat in these stations is evident.

Interstage Leakage of High Pressure Units Must Be Reduced

Remarkably high efficiency ratios are shown by some of the newer turbines, as in the 390-400 non-reheat plant and 610-110 lb. reheat plant. These are respectively 78.3 and 78.4 for the non-reheat plant and 80.7 and 80.0 per cent for the high and low pressure turbines in the 610-110 lb. reheat station. The efficiency ratio of the 1200-lb. turbine in the 1260-300 lb. plant has recently been increased from 74.2 per cent to about 80 per cent, largely by correction of interstage leakage.

ACTUAL STATION ECONOMY IN B.T.U. PER KW-HR. FOR 10 HIGH PRESSURE STATIONS

No.	Month of	Station									
		310 Lb.	330 Lb.	340 Lb.	350 Lb.	360 Lb.	390 Lb.	400 Lb.	570–140 Lb.	610–110Lb.	1260–300 Lb
1	1926—July	17,421	18,803	17,820	17,178	23,787§	16,100	13,800	14,458	13,279	15,606
2	August	17,437	18,982	17,746	17,585	22,090§	16,310	13,800	14,650	13,523	15,697
3	September	20,926*	18,081	17,266	17,160	21,892§	16,010	13,600	14,772	13,809	15,876
4	October	22,810*	18,942	17,450	17,151	20,784§	15,950	13,700‡	14,508	12,657	15,779
5	November	18,685	18,109	16,948	17,241	19,294	16,030	13,900‡	14,408	12,529	15,572
6	December	16,441	18,360	16,808	17,055	17,920	14,890	14,300‡	15,660	12,495	15,782
7	1927—January	16,200	18,320	17,366	17,909	17,520	15,240	14,200‡	15,063	12,462	15,341
8	February	15,958	18,820	17,500	17,617	18,060	15,340	14,200‡	15,145	12,555	15,077
9	March	20,714*	18,645	17,780	16,077	17,494	14,730	13,800	14,590	12,825	15,257
10	April	27,000*	18,750	17,684	17,784	19,059	14,880	13,800	14,598	15,442†	15,734
11	May	27,008*	18,493	18,350	17,657	21,269§	14,540	13,700	14,947	15,650†	15,855
12	June	27,394*	18,116	19,140	18,098	20,114§	14,680	13,800	14,305	15,396†	15,724
13	Average	18,055*	18,535	17,654	17,376	18,224§	15,390	13,880	14,759	12,904†	15,608

*Light load due to water power. Weighted Average.
§Light load due to water power. Not in yearly average.
‡Two low pressure wheels out on one main turbine.
†Several stages out on both main turbines. Not in yearly average.

Comparing Rankine cycle efficiencies, the reheat plants above 550 lb. pressure show 40.7 per cent efficiency, 15.7 per cent better than the 35.8 per cent average of the non-reheat plant of 400 lb. pressure and lower.

3. Extraction gains, as a rule, increase with the turbine throttle pressures, which agrees with theory.

4. Boiler unit efficiencies are higher in the newer stations employing a combination of economizers and air heaters, as well as radiant heat absorbing surface in the furnace.

5. Two non-reheat plants report over 78 per cent turbine efficiency ratio and one reheat station reports a value of over 80 per cent. The 1200-lb. turbine in the last station tabulated, by reason of correction of interstage bleeding, now has an efficiency ratio of about 80 per cent.

6. Auxiliary power consumption is higher in the stations with more heat saving equipment, although most of them are fairly close to the average of 4.4 per cent. Feedwater pump energy in high pressure stations apparently does not penalize them greatly.

7. Total operating losses vary widely from 3 to over 13 per cent of the total output. Of the individual losses the most variable and also the largest is that due to banking and starting of cold boilers.

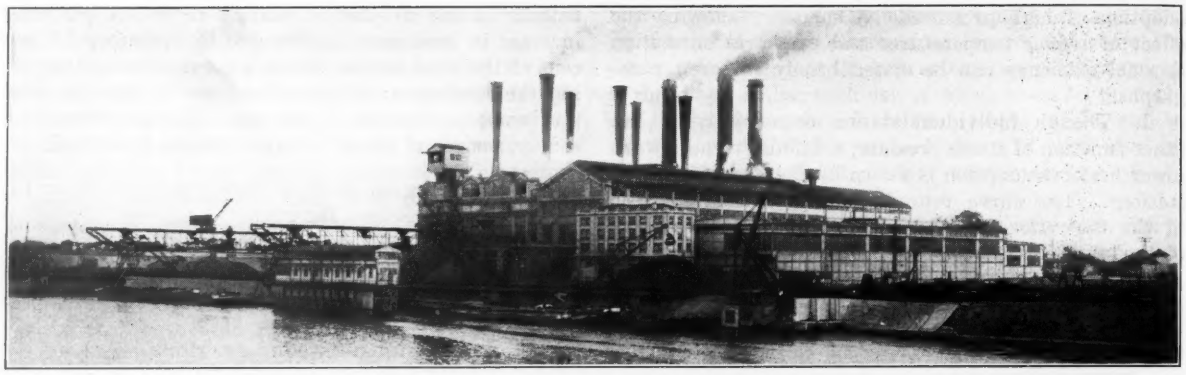
That station economy is not entirely influenced by steam pressures and temperatures is shown by the scattered economy points on the curve shown. These are actual economy results of 10 stations operating at a standard steam temperature of 700 deg. F. and represent the most economical months of the year from July, 1926, to June, 1927, inclusive.

Other than design and steam conditions the only obvious condition effecting turbine efficiency is the exhaust pressure. The 330-lb., 340-lb., 360-lb., 1260-300-lb. plants have machines which were at 75 per cent or lower, in the month reported, and all of these stations have excessively low exhaust temperatures, the resulting large leaving losses penalizing the unit.

Theoretical heat consumption of high-pressure stations increases less at low load than that of lower pressure stations. Increased heat consumption of 8.5 per cent occurs when 150 lb. pressure plant operates at half its most economical load, while the corresponding figure for a 1200-lb. station is 6.6 per cent. Load factors of 70 per cent or over are reported by six of the stations.

Throttling losses in turbine governing are less at high pressures and, from an economy standpoint, the higher pressure is slightly better adapted to high load factor plants than is lower pressure. It should be noted, however, that the gain made in actual installations is less than the theoretical gain.

Based on actual operating experience, high pressures appear to place no handicap upon turbine efficiency. The excellent efficiency of moderately high pressure machines as recorded in steam station data supports this conclusion.



Gennevilliers Power Station Expansion

Two 50,000-Kw. Units at 415 Lb. and 770 Deg. F. Added to Use Pulverized Coal, Stage Heating and Air Preheating. By Marc Hentsch*

CONNECTED TO a network which covers Paris and suburbs, to which other stations at Vitry (80,000 kw.), Eguzon hydroelectric plant (50,000 kw.) and occasionally stations in the north of France feed current, the Gennevilliers station has recently been enlarged by two 50,000-kw. units to a capacity of 340,000 kw.

Generation is from steam at 415 lb. and 770 deg. F. to current at 60,000 v. transmitted by underground lines except for an overhead line to Creil, 34 mi. north of Paris and one to Puiseaux, 22 mi. northwest. Also the line connecting to Eguzon, 186 mi. south, is overhead in two sections, one of 150,000 v. and the other of 90,000 v. Current is supplied to the Paris suburbs and to the Paris-Orleans railway.

*Engineer of La Cie. Electro-Mecanique.

In the station are to be found a variety of units, two Escher-Wyss, three Society Alsacienne de Constructions Mecaniques, one Schnieder du Creusot—all 40,000 kw.—and the two 50,000-kw., No. 7 by La Societe Alsacienne de Construction Mecaniques on the Zoelly system with impulse wheels, No. 8 by La Compagnie Electro-Mecaniques on the Brown Boveri system with reaction blading, having two impulse wheels in the high-pressure cylinder only.

Both turbines have three cylinders. They are rated at 360 lb. pressure, 710 deg. F. temp., and 96.5 per cent vacuum, 1500 r.p.m.

For the No. 7 unit, the three cylinders are on the same axis, the high-pressure having seven stages, intermediate ten and low-pressure double flow with two

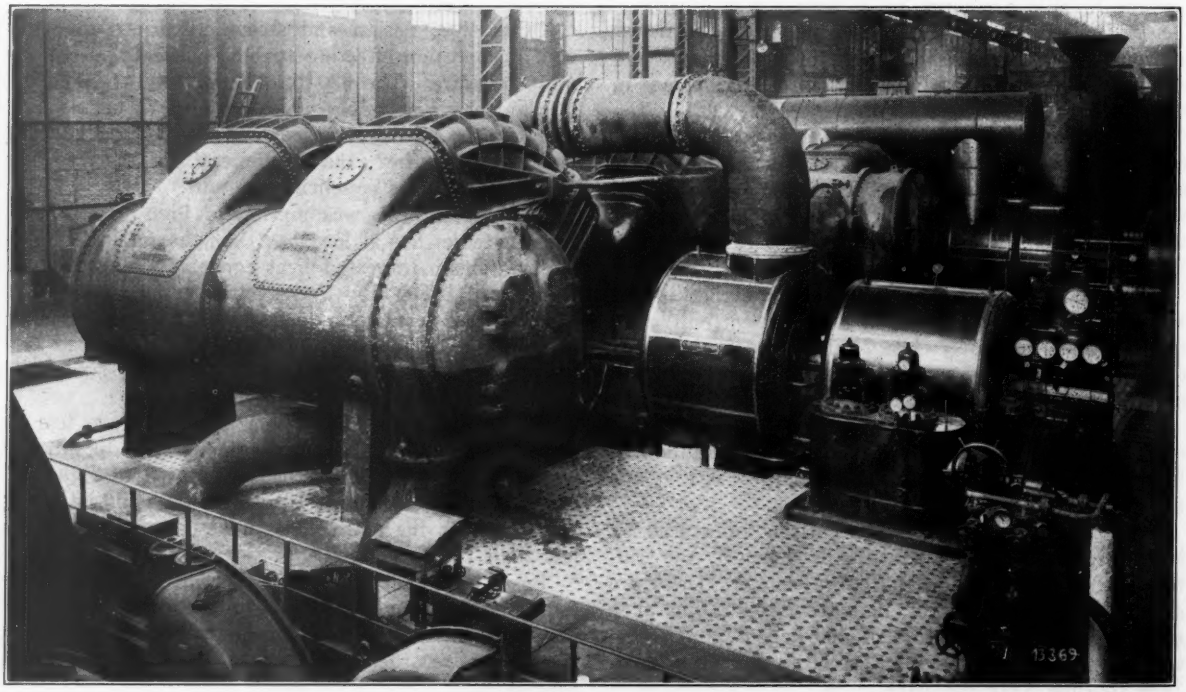


FIG. 1. THREE-CYLINDER TURBINES, EACH HAVING FOUR CONDENSERS, TWO ABOVE AND TWO BELOW THE FLOOR

stages to each flow. Flexible couplings, allowing for expansion, join the shafts of the three cylinders.

In No. 8 unit, steam flows through the high and intermediate pressure drums in opposite directions, the reaction being so proportioned that net axial thrust is reduced to a small value. The low-pressure cylinder is double flow, hence self balancing, so that a balancing piston is avoided. Two thrust bearings, each combined with a shaft bearing, care for the slight net axial thrust. One is placed between the high and intermediate cylinders, which have a single rigid shaft, and is secured to the base plate and to the cylinders. The second thrust bearing is in front of the low-pressure cylinder, which has a separate shaft, joined to the other by a Parsons flexible coupling. A similar coupling connects to the generator shaft.

Turbine Details

Cast steel is used for the high-pressure cylinder, cast iron for the others. Blades of the high-pressure rotor are of five per cent nickel steel, for the intermediate, brass, also for the first rows of the low-pressure but the last rows are of stainless steel to resist high centrifugal stress and the erosion due to wet steam.

Steam admission in No. 8 is through four automatic valves, secured in pairs to castings on either side of the high-pressure cylinder and opening in succession to reduce throttling loss. The first opens from zero to half load, the second from half to full load, the last two, on overload, open successively to pass live steam by the impulse wheels directly to the reaction blading.

For No. 7 throttling valves are used, regulated through levers by the governor to open in succession as needed, but bypass is not provided. Regulation, zero to full load, is within four per cent.

Oil regulation is used, the oil pump supplying both regulator and bearings. This pump, driven by a small steam turbine, sends the oil through a water-cooled system before going to the bearings.

Overspeed governors are provided to come into action if speed reaches 10 per cent above normal.

Condenser Arrangement Is Unique

Four condensers are installed for each unit, each with two steam inlets. They are arranged two above the floor, as seen in Fig. 1, and two below the floor at right angles, the object being to equalize pressures at all points of the circumference of the low-pressure cylinder and to reduce pressure loss between cylinder and condensers. The condensing plant for No. 7 unit was furnished by La Societe des Condenseurs Delas, including motor-driven circulating and condensate pumps and steam ejectors. For No. 8 unit, a similar equipment was supplied by La Societe de Condensation et d'Applications Mecaniques.

Condensate takes up heat before going to the boilers, first from the cooling air from the generator system, next from the lubricating oil, then from steam bled from two stages of the turbine. The temperature is thus raised to 195 deg. F. and, finally, the economizer brings it to 290 deg. F.

Designed for most economical operation at 200,000 lb. of steam an hour and maximum for a 2-hr. period of 245,000 lb. an hour, each, the four Ladd-Belleville boilers are of three-drum type. They are for a steam pressure of 415 lb. per sq. in., superheat to 770 deg. F. and with water space for 127,000 lb. Heating surface of 19,700 sq. ft., superheating surface of 5150 sq. ft. and economizer surface of 14,000 sq. ft. are provided.

Pulverized coal is fed through twelve burners per boiler into a combustion chamber of 11,800 cu. ft. volume, the Lopulco-Ronbaix system being used.

Coal for two pulverizers is dried by Huilard dryers, for other pulverizers by bypassed flue gases, the moisture being reduced to 2 to 3 per cent. After pulverizing, the coal is lifted by air to the upper part of the boiler room and passed through cyclones, which deliver to screw conveyors.

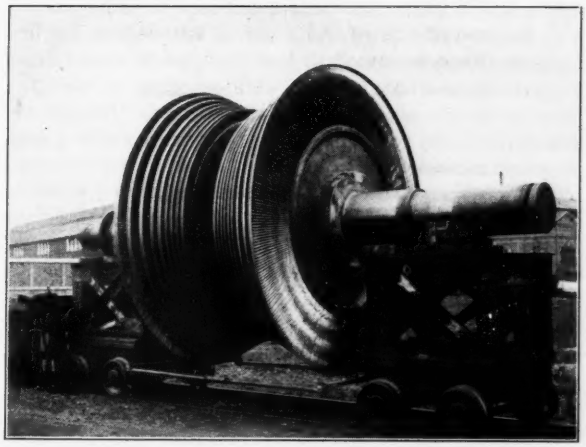


FIG. 2. DOUBLE-FLOW ROTOR FOR LOW-PRESSURE CYLINDER REQUIRED SPECIAL CARS FOR TRANSPORT

Primary air (about 15 per cent of the total) is preheated by passing through double walls under the ash hopper. Secondary air flows through passages in side and front walls, being heated to from 210 to 250 deg. F., and enters the combustion chamber through openings in the front walls. Ashes fall through a water-tube screen to the hoppers.

Both generators were furnished by La Societe Alsacienne de Constructions Mecaniques. They have a rating of 60,000 kv-a. at 6000 v., three-phase and 50 cycles per second. Rotors are interchangeable and also with that of unit No. 6 of the older installation.

Switching Equipment

Current is stepped up to 60,000 v. by single-phase, oil-cooled transformers. Each unit has a main automatic oil circuit breaker, three motor-operated oil breakers, for connecting to any one of three sets of bus bars, and various feeder switches. All switching is done on the high-voltage side, transformers of 60,000 to 3000 v. providing current for auxiliary motors.

On the upper panel, in front of the operator is a dummy layout of the high-tension lines on which the operator reproduces the switch connections. If the dummy does not agree with the actual connections, a signal lamp lights to call attention to the place where the error has occurred.

As indication of the size of some of the parts, Fig. 2 shows the low-pressure rotor of No. 8 turbine and the special means necessary for transportation.

Records Lead to Lower Rates

AFTER OPERATING for a period of about 17 yr., much of the equipment of the municipal power plant of the Village of Quincy, Michigan, was found, in 1919, to be in poor condition and some of it was obsolete. Operating expenses had been high and the uses for electricity had increased to a point which left the equipment inadequate for the increasing demands.

At this time a thorough survey was made which resulted in the village council voting to install a Diesel engine electric-generating plant with motor-driven centrifugal pumps for fire and domestic service. Before the contract for the new equipment was signed, however, an investigation was made to determine the possibility of central station service but, at that time, there was no supply of electricity available at reasonable rates.

Originally the plant was equipped principally with two 150-hp. boilers and a 12 by 18-in., high-speed steam engine belted to a two-phase, revolving-armature, 75-kv-a., 60-cycle alternator and a 10 and 18 by 10-in. vertical compound steam engine direct connected to a two-phase, 50-cycle, 50-kv-a. alternator. Two Diesel engines, one of 100, the other of 200 hp., direct connected to 75 and 170-kv-a. alternators respectively, together with the necessary auxiliaries, were then installed at a total cost of $36,000. Necessary alterations and additions to the plant increased this cost to $40,000.

Due to delays, it was not until 1921 that the new plant was put in complete operation. At this time, R. J. Brokaw, superintendent of the electric light and water works plant of the village, and Professor R. S. Hawley of Ann Arbor, Michigan, consulting engineer for the village, established a simple but effective system of record-keeping, so that actual costs of power production were thereafter available.

Demand for electricity increased rapidly and, in 1927, the peak load taxed the capacity of the engines. A new survey was then made to determine the advisability of purchasing additional equipment or of buying power from the Consumers' Power Co., whose lines were established nearby. In August, this company purchased the village plant and distribution lines and was granted a franchise to distribute and sell current directly to consumers and to the village for lighting and pumping.

Table I gives the expense items taken from the report made to the village by the consulting engineer.

Table II, taken from the rate schedule that was adopted when the Consumers' Power Co. took over the plant, gives the different charges for service except that for street lighting, which was put on a flat rate per month. Under the present franchise, these rates cannot be increased.

TABLE I. RECORD OF COSTS FOR 1925

Fuel oil	$4313.03
Lubricating oil	835.32
Kerosene oil	49.54
Oil, total	$5197.89
Engineers' Salaries	4814.75
Portion of Superintendent's Salary	500.00
Labor, total	$5314.75
Plant Repairs and Supplies	1699.00
Salt for softener	43.07
N.Y.C. rental	10.00
Telephone & telegraph	75.00
Printing and Stationery	100.00
Workman's Compensation Insurance	227.50
Repairs and Supplies, total	$2154.57
Grand total	$12667.21

Kw.-hr. generated in 1925 427,946

Generating cost, cents per kw.-hr., total 2.96 cents

Generating cost, labor and fuel only 2.34 cents

Fixed Charges

First Cost	Building $11 000	Equipment $29,650.
Depreciation, per cent	3.	6.
Interest " "	5.	5.
Maintenance " "	2.	2.
Total annual rate " "	10.	13.
Annual charge	1100.	3848.

Total annual charge $4948, or 1.15 cents per kw.-hr.

" generating charge 2.96 " " " "

" plant cost at switchboard 4.11 " " " "

Transmission Costs

Line material	$ 720.02
" labor	127.60
Meters	146.30
Transformers	158.09
Lamps	324.72
Supplies and Fixtures	2362.43
Freight and miscellaneous	143.62
Part of Supt.'s salary	500.00
Total Transmission	$4449.78
Total cost, plant and transmission	$22,064.99
or 5.16 cents per kw.-hr.	

TABLE II. PRESENT CENTRAL STATION RATES

Present Central Station Rates, Quincy, Mich.

Service	Fixed Charge Mo.		1st Rate			2nd Rate			3rd Rate		
	Gross	Net		Gross	Net		Gross	Net		Gross	Net
Lighting	$0.55	$0.50	1st 30 kw.hr.	$0.09	$0.08	2nd 30 kw.hr.	$0.07	$0.06	over 60 kw.hr.	$0.05	$0.04
Lighting** cooking & refrign.	0.55	0.50	1st 30 hr. active load*	0.11	0.10	2nd 30 hr. active load*	0.07	0.06	over 60 hr. active load*	0.045	0.035
	Min.Chg.per hp. per Mo.										
Power † 1st 10 hp. connected load	1.00	0.90	1st 30 kw.hr.		0.06	next 70 kw.hr.		0.05	over 100 kw.hr.		0.04
over 10 hp.	0.55	0.50			0.06			0.05			0.04
Pumping, Village††		2.00	1st 60 hr. active load		0.02	next 90 hr. active load		0.0175	over 150 hr. active load		0.016

* Active load is 80 per cent of first 0.5 kw. connected load and 60 per cent of all connected load over 0.5 kw. Cooking capacity at least 2 kw. required. Excluded from connected load are domestic appliances; porch lights, vacant sockets, cooking and refrigeration devices.

** Minimum charge of $1 a month includes fixed charge.

† Discount of 10% on bills paid before discount dates.

†† Rates are net, five per cent added if bills not paid by 10th of following month. Active load is 90 per cent of 1st 5 hp. connected, 80 per cent of next 5 hp. connected, 70 per cent of next 20 hp. connected, 60 per cent of all over 30 hp. connected.

Minerals Affect Feedwater

PROPER TREATMENT DEPENDS UPON SPECIFIC CONDITIONS. BY J. B. ROMER*

IMPURITIES in boiler feedwater result in scale, corrosion, embrittlement, priming and foaming. Scale is responsible for lowered efficiency, blistered and ruptured tubes. Corrosion results in thinning of the metal and may cause early failure or may result in the lowering of the safe working pressure, thereby impairing the usefulness of the boiler. Embrittlement manifests itself by cracking the plate with the necessity of replacement, while priming and foaming cause wet steam and, in extreme cases, slugs of water to pass over to the engine, with its attendant dangers and evils.

Mineral matter present in most water consists of a few acids so combined as to give a number of different compounds. The bases usually encountered are the alkaline earths, calcium and magnesium and the alkalies, sodium and potassium which, for convenience can be referred to as sodium. A number of other bases are occasionally encountered; due, however, to the small amount present they are of slight consequence from a boiler feedwater standpoint. The acid radicals that are present are bicarbonate and occasionally carbonate, sulphate, chlorites and nitrates.

BOILING BREAKS DOWN THE BICARBONATES

Calcium and magnesium bicarbonates represent a somewhat unstable condition. They are in reality calcium and magnesium carbonates held in solution by the presence of carbonic acid. Therefore, any condition which will remove the carbonic acid will immediately result in the precipitation of the calcium, magnesium and carbonate. Fortunately boiling water at atmospheric pressure will not hold gases in solution. Therefore, if the water is heated to the boiling point and held there long enough for the gases to escape, it results in a rather complete removal of the calcium and magnesium bicarbonate. If, on the other hand, the water is pumped direct to the boiler without sufficient preheating, the carbonates will precipitate within the boiler. This usually takes place in the colder parts and the resultant sludge settles out in the mud drum where it can be readily blown out. In the event that care is not taken to prevent these carbonates from settling out on the heating surface, a troublesome scale will soon build up.

Calcium sulphate has a decreasing solubility with increasing temperature. This results in the precipitation on the hottest parts which, in the case of a water-tube boiler, are those tubes nearest the fire. The material readily adheres to the steel tubes and acts as an excellent insulator, preventing the heat from being transferred from the steel to the water. The result is the rapid heating of metal to a point well in excess of the temperature of the water, frequently reaching such a temperature that the steel loses its strength, bulges, forming the so-called blister, and eventually ruptures. When the tube swells or bursts, it cracks the layer of calcium sulphate, permitting the water to reach the hot tubes, forming, in the case of a blister, a steam pocket, or if the tube is ruptured, a sudden flow through the opening. In both cases, the effect is the same, namely, all signs of scale are removed from the immediate neighborhood. This leads many engineers and boiler operators to believe that the trouble is due to defects in the steel and not because of the scale. They point with considerable emphasis to the fact that immediately around the blister or rupture there is no scale present. Investigations show that the steel is entirely satisfactory and that scale is present in other parts of the boiler.

*With the Babcock and Wilcox Co., Bayonne, N. J.

NON-SCALE FORMING SALTS MAY CAUSE CORROSION

In many cases when calcium sulphate is precipitated it mechanically entraps a good deal of calcium carbonate, silica, suspended matter and other solids which are not settled out in the mud drum. The result is a combination of sulphate and carbonate scale. Magnesium sulphate is quite soluble and is not a scale-forming constituent. On the other hand, it has corrosive tendencies which result in the formation of pits and serious damage to steel parts. Calcium chloride and magnesium chloride can be considered extremely troublesome materials. Wherever magnesium chloride is introduced into a boiler and no steps are taken to offset its action, corrosion results. Pits are quickly formed and these eventually become deep enough to penetrate the metal and necessitate replacement of the parts in question.

Sodium bicarbonate is not a scale-forming material nor corrosive in the usually accepted meaning of the word. Due, however, to its eventual hydrolysis to sodium hydrate, it can be classified as a harmful element. Sodium sulphate and sodium chloride are two salts present in practically all waters. They are rarely considered corrosive and are not scale-forming unless concentration is excessive. In the presence of oil, soap or suspended matter, sodium salts are extremely troublesome from the standpoint of priming and foaming. Iron, although present in almost every water, is of no moment so far as boiler feedwaters are concerned, unless it happens to be present in the form of ferrous sulphate, under which conditions the problem is really that of sulphuric acid corrosion.

IDEAL FEEDWATER IS HARD TO OBTAIN

Invariably there is a small amount of silica present in all waters. As a rule, it is of no moment. There are many cases, however, where it becomes a serious problem, especially as it frequently forms calcium magnesium silicate, which produces an exceedingly troublesome scale.

In coal mining districts acid waters are produced, due to the oxidation of pyrites into ferrous sulphate. This is in reality a ferrous acid problem, the result in both cases being extensive corrosion which may also arise in many cases with trade waste.

An ideal feedwater is one that is neither scale-forming nor corrosive and will not cause embrittlement, priming or foaming. Unfortunately, such waters do not exist and it therefore becomes necessary to treat the existent supply so that it will conform to these requirements. This is accomplished by various treatments. In many cases, the treating is done outside of the boiler, therefore it permits making a thorough job. In other cases, efforts are made to treat within the boiler. The results are never as good, because no boiler is a chemical retort.

Limiting Outputs of Automatic Stations

To What Limits Can Automatic Equipment Be Economically Applied in Hydroelectric Plants? Here Is the Answer to This Question. By Donald H. Mattern*

INCREASING INTEREST is being shown in the application of automatic control equipment in hydroelectric generating stations. A little more than 10 yr. ago, the first remote controlled hydroelectric generating station was put into operation at Cedar Rapids, Ia. Since that plant was placed in service, 267 more units have been equipped with automatic control or protective features representing an installed capacity of 455,573 kv.a. or an average of a little more than 1675 kv.a. per unit.

Most of the earlier installations were of very small capacity, from 25 to 50 or 100 kv.a.; however, the average unit has been increasing in size as the control equipment has become more reliable and the knowledge concerning advantages to be derived thereby has become commonly known. This tendency is evidenced by the 10,000-kv.a. Alouette Plant of the British Columbia Electric Co., Ltd., the eight 12,500-kv.a. units in the Falls Station of the Louisville Gas & Electric Co. and the 13,333-kv.a. Glines Canyon Station of the Northwestern Power & Light Co. The last named plant is the largest installation to which automatic control has as yet been applied. This increased confidence in automatic control promises activity in the future, an activity which must soon become evident because of ever expanding load requirements.

Problem to Be Solved

Engineers are now beginning to ask themselves just what is the limit to which automatic control can be economically applied. The writer has gone into this matter a little more extensively than the corporation engineer can find time to do. This article contains the results of this study. Men interested in this subject generally agree that probably the greatest advantage resulting from remote control is the reduction in cost of operation. It is also an accepted fact that the cost of operation, mostly labor charges, decreases as the total generated kw-hr. increases until a point is reached where such cost becomes a small part of the cost of generation. This point is the one at which the additional cost of automatic control equipment is just equal to the reduction in operating expenses brought about by its installation. Beyond this point, installation of equipment to eliminate labor costs is uneconomical and manual operation becomes the logical means of control.

Manufacturers of equipment state that there is no limit to the size of the unit to which they can apply automatic control, so that the question must be considered from another viewpoint than that of technical propriety. Because there is thus no technical limit as to size, the limiting output at which it would pay to install automatic equipment must be decided on the basis of the economics of the particular situation.

When reviewing the question of limiting automatic hydraulic station capacity from the economic viewpoint alone, several intangible advantages are necessarily left out of consideration. Quick availability for service is an especial advantage in all systems where the hydro capacity is used for peak load service, yet no readily definable value can be placed upon its worth to the company. Automatic stations have proved their reliability in every instance and have shown that they may be relied upon for continued service. Safety to apparatus brought about by overload and temperature relays is another somewhat unascertainable advantage of automatic equipment; in fact, so effective are these relays that many such devices are being placed upon units of manually operated stations themselves.

Safety to equipment is further assured by automatic synchronizing as the units are brought on the line, this method being both quicker and more efficient than the manual synchronizing practiced in most non-automatically operated installations. It is the cost in dollars and cents, however, which must be reduced before new types of operation will be adopted, so if it can be shown that operating expenses will be cut below that of manually operated stations, automatic equipment will be installed.

Collection of Data

In order to secure data upon which this question could be studied, one type of questionnaire was sent to every corporation and municipality generating power with the aid of automatic hydroelectric stations, and another to the majority of the companies using manually operated stations. In the first questionnaire, an attempt was made to secure 1924, 1925 and 1926 data concerning:

1. System kilowatt output.
2. Plant kilowatt output.
3. Amount charged to operation.
4. Amount charged to maintenance.
5. Type of control.
6. Reason for adoption of automatic control.

The questionnaire to the manually operated plants contained the same first four items, and then asked for:

5. Amount apportioned to fixed charges.
6. Nature of plant load.
7. Number of units.
8. Number of men.

For example, of the 26,189,000,000 kw-hr. generated by water power in 1926, cost data were obtained for 6,193,000,000 kw-hr., or a little less than 25 per cent of the energy produced. While this figure represents only 25 per cent of the total output, it included a wide distribution of plants throughout the United States and Canada, therefore it can be considered fairly representative of the entire output. Subdivision of the 6,193,000,000 kw-hr. shows that 5,961,192,896 kw-hr. was contributed by 55 manually operated stations and the remainder, or 231,969,693 kw-hr., by 33 automatically equipped generating stations. Few companies allocate fixed charges to individual plants, consequently

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few of the replies contained data concerning that particular item of the manually-operated-station questionnaire; however, maintenance and operation costs were available and the studies were made with them as a basis.

Correlation of Data

Some common basis of correlation of the data was sought whereby figures from 1924, 1925 and 1926 could be used in the same study. Because labor costs comprise most of the total cost of operation plus maintenance, index figures as issued by the Department of Labor covering rates of wages, and then those of Engineering News-Record, were applied to these two items. Before correction it was noticed that the charges varied with the total output of the station; also, individual costs showed little change during the period 1924 to 1926. After correction, however, items assumed values quite inconsistent relative to each other. Large outputs cost more per kw-hr. than did those only fractionally as large, something not to be expected in practice. From further study of this discrepancy, it appeared that the increased efficiency of modern equipment and methods of operation made up for the changed index of the three years taken into consideration. In other words, more efficient operation offset the change brought about by an increase of index numbers from 228.1 in 1924 to 250.3 in 1926. Because of this situation, all figures were used as obtained from the companies without the application of any correction factor.

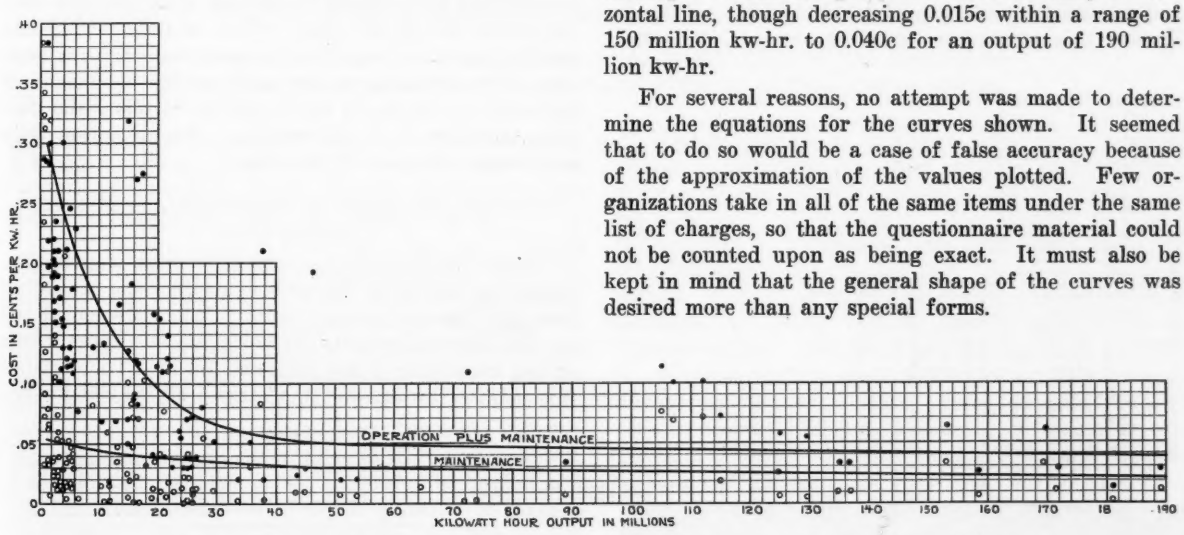


FIG. 1. HYDROELECTRIC STATION COST CURVES FOR MANUALLY OPERATED PLANTS

These curves are based upon figures obtained from 55 generating stations. Small circles denote maintenance. Solid dots denote maintenance plus operation.

Manual Station Costs

From these data of the manually operated stations, Fig. 1 was drawn containing curves representing (1) maintenance alone and (2) maintenance plus operation. They were drawn with the idea of establishing upper limits rather than striking an average of the points under consideration. Costs higher than those shown by the curves immediately lead one to infer that the corresponding installations were not being operated in the most efficient manner, or else, due to some inherent operating characteristics, could not function as economically as the majority of plants considered. It will be observed that the curves as drawn arbitrarily increase the operating cost of manual operation, thus favoring the automatic station. This is believed justified because of the improvements being made in automatic equipment which no doubt will soon be equivalent to this deviation made in its favor; however, an average line, if one should be desired, could be drawn 0.01c lower in each case, although it would have the same general form as the curves already shown.

Cost of Operation Decreases with Increased Output

It is seen that the total cost of operation plus maintenance varies from some large value for outputs of one million kw-hr. to approximately 0.055c for an output of 40 million kw-hr. as defined by a curve hyperbolic in shape. From this point the curve is nearly a horizontal line, though decreasing 0.015c within a range of 150 million kw-hr. to 0.040c for an output of 190 million kw-hr.

For several reasons, no attempt was made to determine the equations for the curves shown. It seemed that to do so would be a case of false accuracy because of the approximation of the values plotted. Few organizations take in all of the same items under the same list of charges, so that the questionnaire material could not be counted upon as being exact. It must also be kept in mind that the general shape of the curves was desired more than any special forms.

Maintenance costs vary little with the total output of the station, as is seen from the change of only 0.02c in 200 million kw-hr. generated. This condition can be explained by the fact that station and equipment upkeep must be continued regardless of plant activity, and is almost independent of the energy produced.

Automatic Station Costs

Figure 2 contains three curves plotted from the data obtained for automatically operated stations. Because it was desired to show the amounts actually charged to the several items, average curves were drawn to demonstrate these conditions. Maintenance costs vary from 0.095c for an output of two million kw-hr. to approximately 0.020c for a 20 million kw-hr. output. This charge is higher than the corresponding manual station maintenance cost only up to an output of five million kw-hr., beyond which the automatic station is the cheaper. This may be explained by the fact that

once automatic equipment is adjusted properly, it requires little further attention. The operation curve varies from 0.120c per kw-hr. to 0.050c per kw-hr for an output range of 20 million. One might expect to find this curve uniform for an automatic plant, but existing operating necessities made this impossible. There are few unattended automatic stations throughout the country, so that the small output installations therefore have a high operation cost per kw-hr. Attendants are needed to clean the intake screens, to inspect pipe lines, shut valves and for other duties for which no entirely satisfactory automatic equipment has been devised.

Limit of Application of Automatic Stations

Using the two diagrams simultaneously, the point may be obtained beyond which economic use of automatic equipment is evidently not possible. Taking the item of operation alone, it is found that at an output of 20 million kw-hr. the costs of generation by automatic and manual installations are equal at 0.050c per kw-hr. Beyond this point, the operating cost of the manual station is less than that of the automatic plant and is therefore the better from the viewpoint of labor cost.

If the operation-plus-maintenance curves were to be used, it would be found from that of Fig. 2 that at an output of 32 million kw-hr. the total cost of the two items is 0.055; from Fig. 1 the cost of this output is also 0.055 for the manually operated stations, using an average value in order that the two curves might be comparatively used. Because operation and maintenance are not always considered in the same way by different companies, it is better to take operation-plus-maintenance than operation alone. The former is therefore more reliable and is used as the basis of determining the economical limit of automatic station output.

It is believed that an output of 32 million kw-hr. is the critical point desired; in other words, the point beyond which automatic control is not economical when considering the items of operating and maintenance expense. The other advantages of automatic equipment make it possible to fix the point on the output axis between 32 and 40 million kw-hr., the actual amount being indeterminate because of the intangible quantities involved.

Inapplicability of Deductions in Exceptional Cases

Unfavorable criticism can be directed against any deduction arrived at in the manner suggested, and the present situation is no exception. As an example in point, reference may be made to the October, 1927, installation of eight units in the Falls Station of the Louisville Gas & Electric Co., which is remotely controlled from an office half-way between it and a proposed steam plant. Yet it is hardly likely that this plant will produce a greater kw-hr. output than 40 million after the steam station is once built, although it will probably do so before. Automatic equipment is particularly valuable at the present time for peak load utilization and there is no reason to believe that this practice will be changed in the immediate future; however, few developments are made under conditions as favorable to automatic equipment as at this Falls Station, therefore it is believed that this exception does not weaken the case of the author.

Comparative Study of Automatic and Manual Station Data

Equal outputs for the automatic and manual stations were tabulated for analysis in the hope of finding some predominant characteristic. Costs were considered for 30 different outputs in which the two types never varied more than a few thousand kw-hr. The smallest was 483,000 kw-hr. and the largest 26,784,000 kw-hr., the latter being the greatest output as yet recorded for an automatic station for which data were available. From this entire group, only four manual stations had a smaller amount charged to operation than did the corresponding automatic station, and these were all between 2,500,000 and 3,900,000 kw-hr. output. For outputs up to 1,250,000 kw-hr., savings amounted in every instance to 45 per cent or over, but from that point varying percentages were obtained. No outstanding characteristic could be deduced from these operation data.

Maintenance costs showed nothing worthy of notice. Half of the 30 tabulations indicated a saving on behalf of the automatic equipment and half showed a saving in favor of the manually controlled installations. The only thing which this seemed to illustrate was the

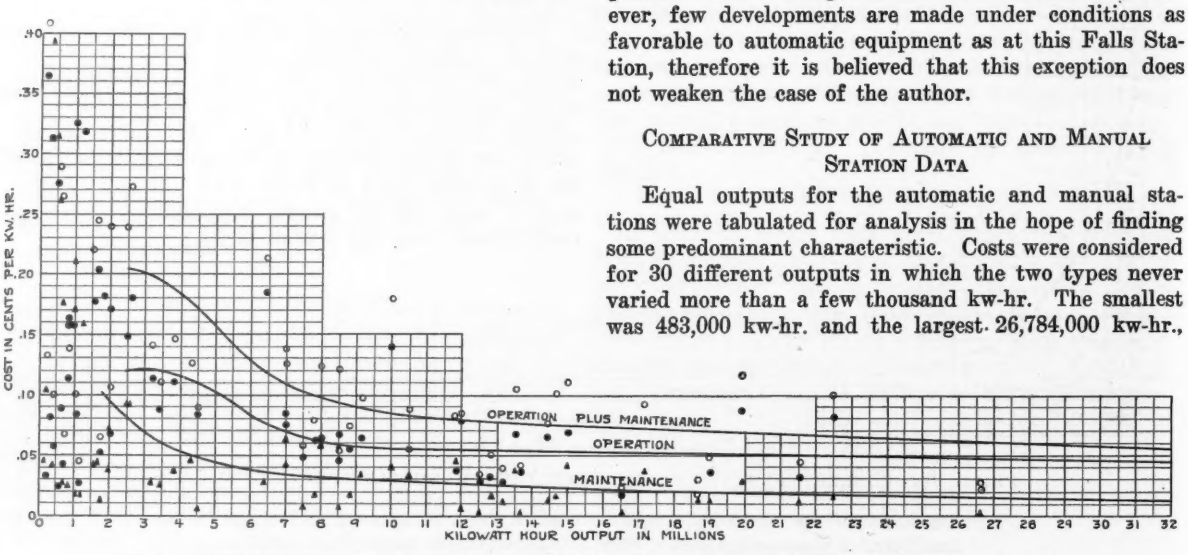


FIG. 2. HYDROELECTRIC STATION COST CURVES FOR AUTOMATICALLY OPERATED PLANTS

These curves are based upon figures obtained from 33 generating stations. Solid dots denote operation; triangular dots, maintenance; small circles denote maintenance plus operation.

idea previously presented, namely, that different companies have different methods of allocating costs of operation and to maintenance, many of them using the operating force for maintenance work but paying their wages from "Operation" accounts.

Conclusions

From these studies, it is concluded that automatic equipment cannot be economically applied to generating stations having an output of more than 20 million kw-hr. when considered from the viewpoint of savings in operating expense alone. On the other hand, when the total operation-plus-maintenance cost is considered, which is a cost corresponding more closely to actual conditions, an output of 32 million kw-hr. defines the limit of application. It is not meant, however, that the use of automatic equipment is not applicable to installations having larger outputs than this stated limit when safety to apparatus, continuity of service, and speed of connecting to the load are prerequisites, even though the economic point of operation has been passed. Therefore an output ranging between 32 and 40 million kw-hr. is the limiting economic output of automatic hydroelectric generating stations. Beyond this point, according to present-day practice, manually operated units should be employed.

Acknowledgments

It is the desire of the writer to acknowledge the assistance given by the many organizations which sent many valuable cost data as well as descriptions of their stations. This study has been made as a part of a thesis for the Master of Science degree in Hydraulic Power Engineering under the direction of Harry N. Jenks, professor in charge of the major work.

Diesel Central Stations Part of Large System

Completeness of Equipment, Excellence of Management and Efficiency of Operation Characterize Diesel Engine Plants of Iowa Power System

RAPIDLY INCREASING numbers of comparatively small Diesel-power, central stations are being established, especially in the middle west and in the south, in connection with large steam stations.

Northwestern Light & Power Co., the Central States Electric Co. and their associated companies, The Iowa Railway and Light Corp., Iowa Electric Co., Middle States Utilities Co. and Central Iowa Telephone Co. which operate throughout Iowa, Northern Missouri and Eastern Nebraska and have established Diesel stations at Correctionville, Armstrong, Perry and Lineville, have built stations at Sibley, Iowa and at Walthill, Neb. respectively and added them to their power system. The plant at Peterson, Iowa, is shortly to have a new 600-hp. Worthington Diesel engine added to its present equipment. One other Diesel station in Iowa that is used principally for peak load service is located at Coon Rapids.

Advantages of Coördinating Power Sources

Many advantages accrue to the companies interested when stations are grouped and under central technical control; records of the interconnected plants may be compared, different methods of operation may be tested, supervision of such plants may be more expert and arrangement and equipment standardized, relative worth of equipment may be established and, because of electrical interconnection, the capacities of such plants for a given field need not be as large as in the case of isolated plants, therefore the plant load factor may be higher.

Sibley station has a present capacity of 1200 hp.; Walthill of 700 hp. Both were built for continuous service. The latter operates at a power factor of 0.8. At the Sibley plant two identical six-cylinder 600-hp., 17 by 25-in. Worthington Pump and Machinery Corp. four-cycle, air-injection Diesel engines are direct connected to three-phase, 60-cycle, 2300-v., 410-kw. General Electric Co. alternators with 125-v., 15-kw., direct-current exciters.

Walthill station is equipped with three units of gradually increasing capacities in order to permit handling a wider range of loads without reducing the machine load factor unduly. The smallest unit is a 100-hp., type Y, Fairbanks-Morse semi-Diesel, two-cycle, solid-injection engine belted to a three-phase, 60-cycle, 2300-v., 50-kw. Fairbanks-Morse alternator to which is connected a 125-v., 7½-kw. Fairbanks-Morse direct-current exciter. Unit No. 2 is a 240-hp., 12½ by 13¼-in., Worthington two-cycle, solid-injection Diesel engine direct-connected to a three-phase, 60-cycle, 2300-v., 160-kw. General Electric alternator to which is connected a 125-v., 8-kw., direct-current General Electric exciter. Unit No. 3 is a 360-hp., 15¼ by 16-in., two-cycle, solid-injection, Worthington Diesel direct-connected to a three-phase, 60-cycle, 2300-v., 240-kw., General Electric alternator to which is connected a 125-v., 10-kw. direct-current General Electric exciter.

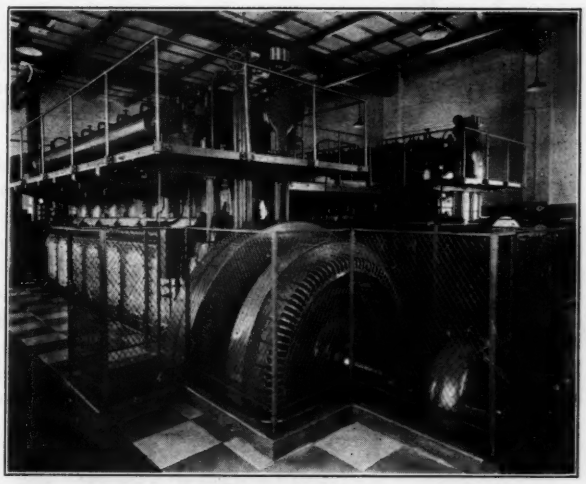


FIG. 1. PROTECTION AGAINST ACCIDENT IS PROVIDED

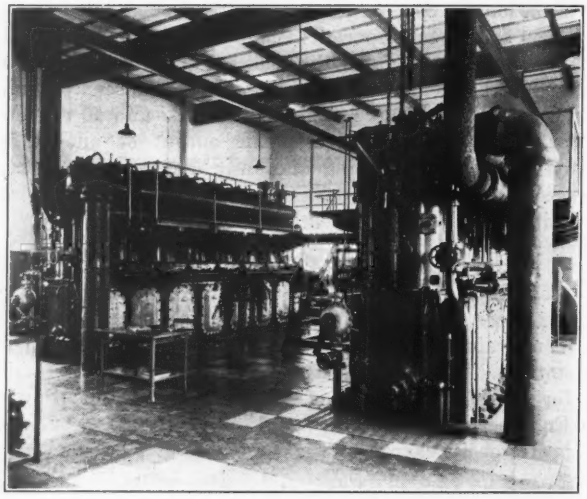


FIG. 2. CLEANLINESS, ORDERLINESS AND REFINEMENT CHARACTERIZE ENTIRE PLANT

Although the air intake is located on the roof of the shop, further precaution is taken to obtain clean air for combustion by providing a Mid-West unit-cell type air filter through which all air for combustion is drawn.

Water cooling is accomplished by means of a cooling tower 34 ft. long and 17 ft. wide by 16 ft. high which is constructed of cypress lumber and fitted with galvanized hardware, distribution box and channels. It is of the series tray type and is supplied with sidewall louvers. Directly underneath the tower is a concrete reservoir 64 ft. long and 17 ft. wide by 5 ft. average depth, which has a capacity of 34,445 gal.

Make-Up Cooling Water Is Softened

Cooling water is circulated by means of centrifugal pumps, a closed system being used and make-up water treated by the zeolite process in a Permutit water-softener which has a capacity of 14,240 g.p.d. Three Worthington pumps, direct connected to 7½-hp. G.E. motors are provided for this purpose. The cooling water enters the jackets at approximately 74 deg. F. and is discharged at about 112 deg.

Fuel oil of 26 to 28 deg. Baumé is received in tank cars on an adjacent track. It is transferred by means of a Worthington triple plunger pump direct-connected to a 3-hp. G.E. motor to three reservoir tanks each of which has a storage capacity of 19,200 gal. These tanks are equipped with heating coils and are so arranged that both light and heavy fuel oils may be stored. From these reservoir tanks the oil is pumped to the day-supply tanks from which it is drawn for the combustion process by a gear-pump having a capacity of 5 g.p.m.

Recording Instruments Aid Management

Completely equipped with electrical recording instruments, the switchboard is supplied throughout with G.E. equipment. Switches on the outdoor switching station, which is located adjacent to the building, are remotely controlled from the switchboard in the station. The current generated is transformed from 2300 to 13,200-v. at this station and distributed to the different towns served. At present 12 towns are served with electric power and light, but in a very short time the towns of Boyden, Hull, Doon and Alvord will be added to the load.

Other instruments for observing and regulating the operation of the engines such as Brown high-resistance electrical pyrometers which show the temperature of exhaust in any cylinder are also installed. Tycos thermometers and barometer provide other data for refinement of operation. Through the use of the pyrometers, improper operation of the engines such as faulty valve adjustment, leaks and unequal loading of the cylinders is at once indicated.

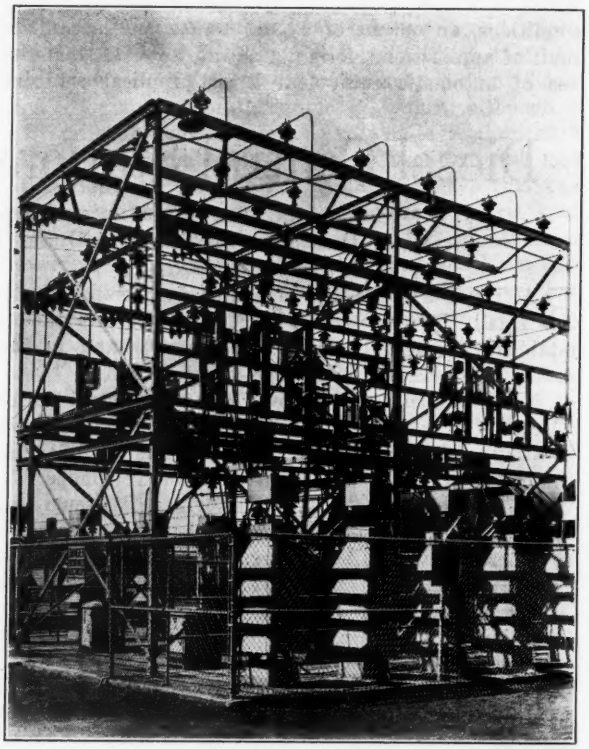


FIG. 3. OUTDOOR SWITCHING STATION IS EQUIPPED IN MODERN CENTRAL STATION MANNER

Brown rotary moisture-proof switches are provided for each pyrometer indicator so that the exhaust temperature in the various cylinders of an engine may be seen by merely turning a knob and in this way such temperatures are readily compared and by this means, Mr. Wells, the Division Manager in charge of the Sibley station, says that fuel is saved, service interruptions are prevented and the operator is relieved of anxiety.

Equipment and Arrangement Are Standardized

Standardization of building as well as of equipment, has also been carried out to a considerable degree; the buildings of the Sibley and Walthill plants are, therefore, quite similar in appearance and construction. The building at Walthill is 61 ft. long, 53 ft. wide and 25 ft. high with full basement 10 ft. 6 in. deep. It is of all brick construction, steel roof structure with gypsum block roof deck and six-ply built-up roof. The shop adjoining is 30 ft. long, 16 ft. wide and 11 ft. high with

full basement. The building at Sibley is 61 ft. long, 45 ft. wide and 21 ft. 6 in. high with full basement 10 ft. deep. It is of all concrete and brick construction, with roof construction the same as that of the Walthill plant. Shop adjoining is 52 ft. long, 16 ft. wide and 11 ft. 6 in. high with full basement.

Basement Affords Ready Access to All Auxiliaries

All the auxiliaries in both plants are installed in the basements. In the Sibley plant the two standby air compressors are driven differently; the one by a 7½-hp. G.E. electric motor to which it is belted; the other is direct connected to a 7-hp. Schramm gasoline engine. Both compressors are of the vertical type; the former is capable of supplying air under 1000-lb. pressure. hence could be employed in an emergency to serve the air for fuel injection purposes; the latter compressor can carry a pressure of 250 lb. which is sufficient for starting the engine. A Sharples oil purifier and the lubricating oil reservoir are also located in the basement. Almost all of the piping of the plant is exposed and located in the basement. Shower baths and steel

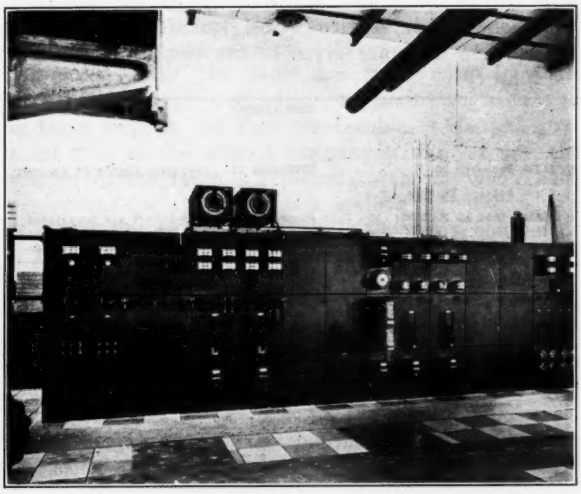


FIG. 4. SWITCHBOARD IS COMPLETELY EQUIPPED WITH INDICATING AND RECORDING INSTRUMENTS

lockers for the operators are also provided in that part of the building.

Both buildings have abundant natural and electric light and are similarly heated by means of small Murray Iron Works vertical shell boilers supplying steam through reducing valves. A pressure of 25 lb. is used. A sump for the heating system return condensation is located in the basement.

Shop Provides Means for Quick Repairs

Equipment of the repair shop in each plant is exceptionally complete. The principal equipment consists of an engine turning lathe, a drill press and an emery wheel all electrically driven. Durant Steel Locker Co. steel shelves and lockers are provided for storage of parts and for tools.

Standardized inspection methods are used in these plants. Schedules are followed for the different parts of the engine, some of which are inspected weekly,

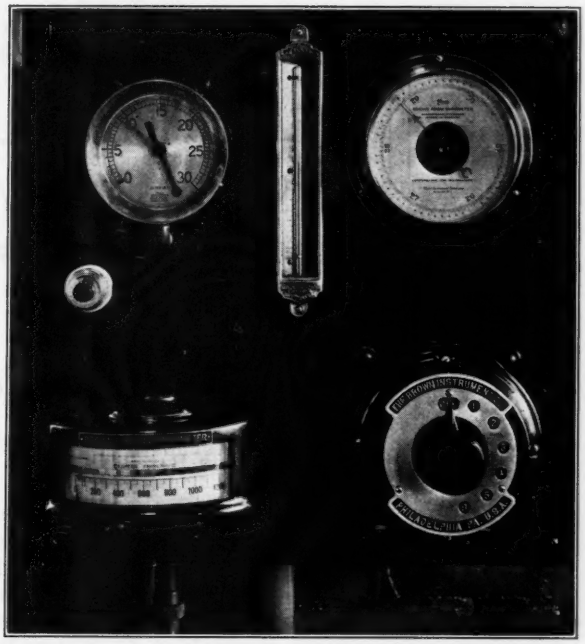
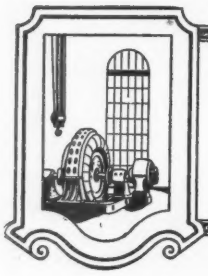


FIG. 5. PANEL FOR TEMPERATURE INSTRUMENTS CONVENIENT FOR OBSERVATION

others monthly. Some, such as suction valves, are reground quarterly and parts such as the pistons, main bearings and governors, are inspected carefully every year. By means of this almost continuous inspection and replacement of parts before they become greatly worn, high efficiency of operation is maintained, service is made dependable and depreciation of engine reduced to a negligible amount.

Both of the plants described, as well as other similar plants of this power system, take on the atmosphere of large central steam stations in that evidences of careful selection and care of equipment as well as of efficient management of plant are at once apparent. Moreover, the same zeal used by central steam stations in capturing all possible available heat units also has been carried over to these Diesel plants. In this the large power system has a manifest service to render. The Iowa system has performed this service with distinction.

FIG. 6. ACCESSIBILITY AND CLEANLINESS CHARACTERIZE BASEMENT OF PLANT



ELECTRICAL MACHINERY FOR LIGHT AND POWER

Organization of Voltage Complaint Department

DESCRIPTION OF A COMPLAINT ORGANIZATION USED BY A LARGE POWER COMPANY WHICH HAS BEEN FOUND SATISFACTORY. BY MAURICE D. SMITH

FEW ELECTRIC LIGHT and power companies are immune to voltage complaints. Some of these complaints are justified while others are unfounded and are often the result of the customer being unfamiliar with the type of electric service to be expected. Most electric companies maintain a complaint department to investigate reports of irregular service made by customers, regardless of the nature of the complaint. It is the object of this article to pass along to others an organization and system similar to that which has been inaugurated by one company and has been giving satisfactory results for some time.

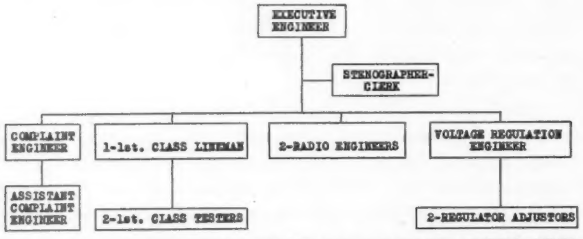


FIG. 1. ORGANIZATION CHART OF VOLTAGE COMPLAINT DEPARTMENT

In this company, the majority of complaints are received by the commercial department and are forwarded to the executive engineer in charge of maintaining voltage on the system, who is also responsible for the complaint until a satisfactory conclusion has been reached and it has been completed. The executive engineer is in charge of the organization shown by Fig. 1, which is sufficient to handle the complaints on a system of 300,000 meters or an average of 5 to 10 complaints a day. On a smaller system, the assistant complaint engineer, one tester, one regulator adjuster and one radio engineer may be dropped.

Functioning of the organization is as follows:

1. A complaint is received by the executive engineer, who turns it over to the complaint engineer.

2. The complaint engineer makes an investigation of the records, such as feeder and secondary maps for any clue that might indicate the cause of the complaint. He then turns the complaint over to the assistant complaint engineer with his recommendations for a field investigation.

3. The customer is interviewed during the day by the assistant complaint engineer, who makes all field investigations of voltage complaints. If it is possible to determine the cause of the complaint during the day, this is done with any suggestions for alterations to secondary or service wires, transformer locations, etc. These data are given to the complaint engineer,

TEST REQUEST

DATE: December 15 REQUESTED BY: Assistant Complaint Engineer

TO: Voltage Testers

PLEASE TEST AS FOLLOWS: Mr. John Jones, 11-10 - 50th Street has complained of frequent lamp burnouts. Take indicating voltage readings at customer's lamps and meter. Also at transformer.

TRANSFORMER SIZE: 25 Kv.a. TRANSFORMER POLE NO: 32754

TRANSFORMER LOCATION: 50th Street S/O 11th Avenue

APPROVED: Complaint Engineer TO BE MADE Today

FOR TESTERS REPORT

NAME OF TESTER ..... DATE OF TEST .....

COMPLAINANT'S METER			TRANSFORMER			MISC.	
	Volts	Amps.		Volts	Amps.	Volts	Amps.
R - 101			R - 116				
L - 103			L - 116				
R - 204			R - 232				

REMARKS: Consumer using 115 volt lamps.
Trouble apparently due to some secondary wire.
Suggest replacing same.

FIG. 2. TEST REQUEST AND TESTERS REPORT FORMS

also a report is made if no trouble can be located during the day.

4. Then the complaint engineer makes a pencil drawing calling for the necessary changes. A work order is made from this drawing and plans are issued to the Construction Division. The Construction Division gives preference to Complaint Work Orders and executes them immediately.

5. If it was impossible to locate the cause of the complaint during the day, a test request is made on the form shown in Fig. 2 and given to the test crew with all information necessary (including a secondary sketch) for them to investigate the condition during

the evening and find the cause. Their report is forwarded to the complaint engineer, who issues the necessary orders the following day to rectify any wrong condition.

6. Upon completion of any work orders or changes in the system, the test crew are dispatched again to take indicating voltage readings on the customer's premises to determine whether the condition has been rectified and whether the customer is now satisfied. If so, the complaint is closed with a memorandum to the commercial department advising what changes have been made and that conditions are now satisfactory to the customer. The commercial department then advises the customer by letter that the condition has been cleared and the matter closed.

Radio Complaints Are Taken Care of by Competent Radio Engineers

When a radio complaint is received by the executive engineer, he forwards it to the complaint engineer, who in turn makes out a test request and forwards data available to the radio engineers. These engineers are equipped with a portable loop receiving set and are first class radio experts. Upon receiving the complaint, they proceed to locate the trouble, working either during the day or the evening. They continue their investigation until the fault has been located. This information is returned to the complaint engineer and he takes steps to see that the trouble is cleared, provided it is on the electric company's lines; if not, the location of the fault is reported to the customer with suggestions as to the proper method of clearing it. Once changes have been made in company equipment or lines, a recheck is made to determine if the condition has been cleared and, if so, whether the customer is now satisfied.

A first class lineman is often needed to take readings of voltage and current on the wires located on poles. In this way, he is busy most of the time. When there are no readings to be taken on the wires on poles, he may be employed to set graphic meters and take other indicating readings on meters and services.

Regulators and Feeder Voltages Are Adjusted by Voltage Regulation Engineer

While the voltage regulation engineer is not directly connected with complaints, his routine calls for keeping the voltage regulators functioning properly and to see that voltage is correct at the load centers of feeders at all times. Occasionally it is found that a complaint is due to poor voltage regulation. In this event, he is notified and proceeds to adjust the feeder correctly. He calculates feeder voltages and issues compensator settings to the Regulator Adjustors, who make the proper adjustments and regulate the feeder with graphic voltmeters located at the load centers to give them indication as to whether adjustments have been made correctly. Another function of the regulation engineer is to keep the feeder loads balanced in the field and station at all times.

Over all is the executive engineer who supervises the organization and keeps a careful check on the status of complaints and if he notices any tend to lag he investigates and starts them moving again.

By having high grade men in the complaint department, efficient and effective results will be obtained. The engineers dealing with customers should be of a high type and pleasing personality.

To facilitate having a report available for ready reference a simple form containing a chronological record of the complaint (which should be on an 8½ by 11-in. sheet of paper) has been found most satisfactory. By having available such an up-to-date record, it is possible for any member of the complaint department to answer intelligently any question relative to the status of a complaint. A separate sheet for each complainant is kept in a loose leaf folder. When the complaint is closed, the report plus all other information and correspondence relating to it are forwarded to the general files.

Once each week, the report shown in Fig. 3 is made out by the complaint engineer and forwarded to the executive engineer. In this way, a positive check is kept upon the progress made by each department involved.

Memorandum to Executive Engineer Date December 15th, 1927.

Status of Complaints

	Week Ending Dec. 15	Week Ending Dec. 8	Increase or Decrease*
Complaints Beginning of Week	22	14	8
Complaints Received During Week	8	5	3
Total	30	19	11
Complaints Completed During Week	10	4	6
Complaints End of Week	20	15	5
Over Four Weeks	4	2	2

STANDING OF COMPLAINTS ON HAND

	Week Ending Dec. 15	Week Ending Dec. 8	Increase or Decrease*
Complaints Awaiting Completion of Test	2	1	1
Over one Week	0	0	
Complaints under Investigation	1	2	1*
Over one Week	0	0	
Complaints Awaiting Changes by Consumer	3	2	1
Over two Weeks	2	2	
Complaints Awaiting Completion of Voltage Adjustment	2	3	1*
Over two Weeks	1	1	
Complaints Awaiting Completion of Plans	3	2	1
Over one Week			
Complaints Awaiting Issuance of Work Orders	1	0	1
Over one Week	0	0	
Complaints Awaiting Completion of Work Orders	6	3	3
Over two Weeks	2	2	
Complaints Awaiting Completion or Retest	2	2	0
Over one Week	0	0	
Total	20	15	

* Decrease

FIG. 3. COMPLAINT ENGINEER'S WEEKLY REPORT

From practice, it has been found that the three records outlined are the only ones necessary and serve to keep all data and progress up to the minute.

Previously, it was stated that not all complaints were justified. This is true, for often, upon investigation, it is found that the trouble is due to the customer's wiring or equipment which has become defective. This is particularly true of radio complaints; however, it is essential that due consideration be given to locating and advising the customer where the fault lies, as he expects and deserves service if he pays for it. When this is done, a new friend has been made for the electric company and we have secured his good will.

Electricity---What It Is and How It Acts*

PART VIII. ELECTRIC CONDUCTION IN SOLIDS, ELECTRON DRIFT, PROPAGATION OF ELECTRIC EFFECT. DIRECTION OF CURRENT

IN AN EARLIER article[1] in this series, it was shown that the three states of matter are accounted for on the basis of molecular agitation. In gases, the molecules are widely scattered with no cohesive forces acting to keep them together; in liquids, they are spaced more closely with slight cohesive forces acting between them; while in solids, they are spaced so closely and are bound by such powerful cohesive forces that there can be little

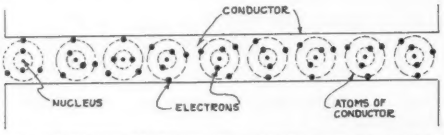


FIG. 1. REPRESENTATION OF ATOMS IN A SOLID CONDUCTOR WHEN NO CURRENT IS FLOWING

The atoms are all normal atoms. Although they are in a state of agitation, each one tends to maintain its normal number of electrons. Occasionally one may be lost in collision but when this happens another electron is acquired from an adjacent atom.

or no relative motion. What motion there is in solids is vibratory in character rather than translatory as it is in gases and liquids.

Electric conduction in solids, therefore, must be of a different nature from that in liquids and gases, for there can be no movement of ions through solids nor can there be an unimpeded movement of free electrons as there is in the vacuum tube. Conduction in solids must be explained on a different basis.

SOLID CONDUCTION DUE TO INTERCHANGE OF ELECTRONS BETWEEN ATOMS

Solid conduction, and when we refer to solids here we do so with particular reference to metals, is due to an interchange of electrons between atoms. The atoms of most metals have, in addition to the electrons which form the stable inner orbits, one or more electrons in the extreme outer orbit which are easily removed. These electrons, in fact, are little more than hangers on; if no disturbing forces are present, they remain with the family but will leave home with the slightest encouragement. It is to the wandering proclivities of these electrons that we attribute metallic conduction.

Consider a bar or block of metal. The atoms in it will be spaced close together, so close that they are

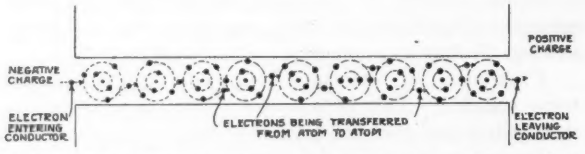


FIG. 2. REPRESENTATION OF ATOMS IN A SOLID CONDUCTOR CARRYING CURRENT

In this case, due to the existence of a difference of potential between the ends of the rod, electrons enter the conductor at the negative end. This gives the atoms at that end an excess of electrons so they transfer one of their own to the next atom. This occurs all along the line, giving rise to an electron "drift" through the rod.

*All rights reserved.

[1]Part V, page 778, July 15 issue.

limited in their movement and are prevented from making any extended excursions from their normal positions. Under these conditions, the external electrons in the outer orbits of adjacent electrons at times will come close together. Occasionally, an electron belonging to one atom will actually come within the sphere of influence of the nucleus of an adjacent atom, thus tending to satisfy simultaneously the demands of the two atoms. When this occurs, one of the atoms will release its hold on one of its electrons, permitting it to wander off to another nearby system which, due to having lost an electron in this manner, needs it. Since the process is duplicated simultaneously in billions of atoms throughout the bar of metal at any instant, there will be billions of these wandering or free electrons in existence. The freedom of these electrons is similar to the freedom of the molecules of a liquid and just as the latter are restrained from leaving the liquid by the attraction of the surface atoms, so are the electrons in a metal restrained from leaving the metal by the attrac-

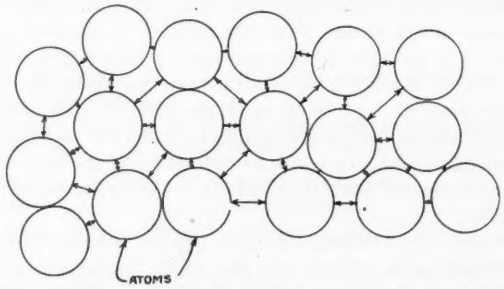


FIG. 3. DIAGRAM ILLUSTRATING WHAT IS MEANT BY THE "MEAN FREE PATH" OF THE ATOM

In any substance, the atoms or molecules are in continual vibration. Each atom is capable of traveling only a short distance before colliding with another. At a particular instant, the length of the lines between the atoms represents the distance which each atom can travel before colliding with another atom. The average of all these distances for all the atoms is the "mean free path" of the atom.

tion of the atoms at the boundary of the metal. Under certain conditions, as we shall see later, some of the electrons may be made actually to leave the metal.

NATURE OF THE ELECTRON "DRIFT"

Suppose now that we connect the two ends of the bar of metal we are considering to a source of electric potential so as to establish an electric field through the bar. Not a great deal of imagination is required to see what will happen. The free electrons under the action of the electric field will at once be drawn in the direction of the positive terminal of the bar although their progress will be impeded by countless billions of atoms in their path. There will be innumerable boundings back and forth and a single electron will undergo innumerable "captures" and "releases" but if the sum total of all the free electrons is considered, there will be superimposed upon the haphazard motions of the electrons, a directed motion along the lines of force constituting the field toward the positive end of the rod.

There will be a "drift" of electrons towards the positive end. This "drift" of electrons constitutes what we know as an electric current. It will be well to remember this fact, that electrons in motion constitute an electric current.

Speed of Electron Drift

Now the value of the electric charge represented by a single electron is exceedingly small and to produce a current of appreciable strength, the motion of billions of electrons is necessary. To make a current of even one ampere, it is necessary that 10^{19} (ten million, million, million) electrons pass by a given point in one second. If a counting machine were constructed which would count this number of electrons at the rate of

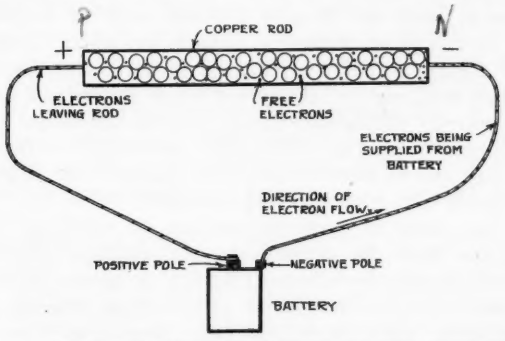


FIG. 4. ELECTRIC CURRENT CAUSED BY THE "DRIFT" OF ELECTRONS THROUGH A METAL ROD

one million per second, the machine would have to be operated continuously, day and night, for over 317,000 years.

Despite this enormous number, the progressive movement of electrons in a metallic conductor is exceedingly slow. If we accept the assumption that there are as many free electrons in a piece of copper wire as there are atoms, to produce a current of one ampere in a copper wire one millimeter in diameter requires that the average velocity of the electrons be only about 0.001 cm. per sec.[2]

Note that we say *average* speed. The velocity of the individual electrons is very high. Even when no current is flowing in a wire, the electrons have a haphazard motion due to thermal agitation of the atoms of about 35 mi. per sec. The average velocity under these conditions is, of course, zero; there are just as many electrons moving one way as another.

Slow Average Speed of Electrons Due to Collisions

The reason for the extremely slow progressive movement of electrons in a wire or rod is to be found in the tremendous number of collisions they have with the molecules and atoms composing the metal. Electrons moving toward the positive end of the conductor cannot travel far before colliding with atoms or molecules. Since the atoms and molecules are many thousands of times more massive than the electrons, the latter rebound from the atoms with practically the same velocity as that with which they approached the atoms. Naturally, at any instant there are almost as many electrons moving in a negative direction as there are in a positive direction.

[2] Morecroft, Principles of Radio Communication, page 11.

If it were not for the innumerable collisions experienced, an electron in a metallic conductor would gain a tremendous velocity in an extremely short interval of time, since only a small potential gradient is required to accelerate an electron rapidly. But the mean free path between successive collisions is small and because of this the velocity acquired by an electron due to the potential gradient is extremely small. As the potential difference between the ends of the conductor is increased, the average velocity toward the positive end increases but slightly. With a current so large that the copper wire is heated to the melting point, the drift of electrons is less than 1 cm. per sec.

As long as a difference of potential is maintained between the ends of the conductor, there will be a drift of electrons toward the positive end. If the ends of a copper rod are connected to the poles of an electric battery as shown in Fig. 4 the electrons move slowly towards the end P. When they arrive at P, they leave the rod and travel down the wire to the positive pole of the battery, through the battery to the negative pole, through the other connecting wire and back to the rod. As fast as the electrons leave the end P, they are supplied at the end N. The cause of the flow is, of course, the battery, which, by virtue of the chemical action within the cells, maintains the ends of the rod at a constant difference of electric potential or pressure. The action would be the same if the difference of electric pressure was produced by any other means, say by a dynamo, or by an old-time frictional machine. A battery or generator, therefore, is virtually a pump for pumping electrons through the system.

John Mill's Analogy

Varous analogies have been resorted to for explaining metallic conduction and while all of them are helpful in obtaining an understanding of the phenomena, none in the author's opinion is more ingenious than

FIG. 5. CONDUCTION IN SOLIDS MAY BE LIKENED TO THE ACTION OF A GROUP OF PLAYERS ON A BASKET-BALL COURT

The players are the atoms and the balls the electrons. As additional balls are tossed into the court at one end, there is a progressive movement of balls to the opposite end where they are expelled from the court.

the one given by John Mill.[3] Mr. Mill pictures a metallic conductor as an enormous basket ball court on which there are disposed a large number of players. Each is assigned to a relatively small circular space within which he is free to move. The space may, however, overlap into the space occupied by one of his neighbors so that even within his one area of action a player's movements are sometimes restricted by the necessity of avoiding a collision with his neighbor.

Suppose, now, that a large number of balls is tossed to these players so that each player has a ball, and let them begin to toss the balls to each other. The balls

[3] Within the Atom.

correspond to the wandering electrons and the players to the atoms. If a player with a ball in his hand finds another ball being tossed to him, he will find difficulty in holding both of them, so he tosses the one he has in his possession to some other player in order to make room for the one he has just received or will receive. At any instant, a number of balls will be in the air but none of them ever leave the court.

If, now, at one end of the court we toss into it a certain number of additional balls and at the opposite end remove a similar number, it will be obvious that the players at the receiving end will not be able to handle all of the balls and there will be a general movement of balls to the end of the court where there is a

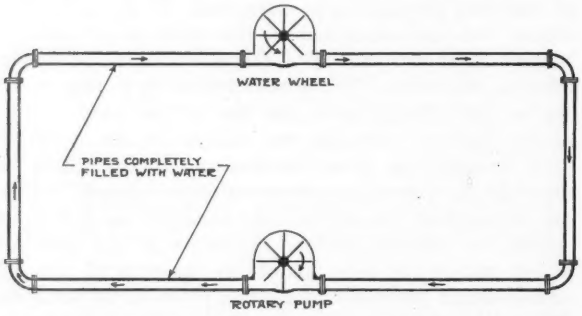


FIG. 6. HYDRAULIC EQUIVALENT OF AN ELECTRICAL CIRCUIT TO ILLUSTRATE THE SPEED OF PROPAGATION OF AN ELECTRIC CURRENT

When the pump is started, the water wheel begins to turn almost immediately, although the water from the pump may not reach the water wheel for a long time afterwards.

deficiency. This general movement of the balls towards the exit end will be superimposed upon the haphazard motion which existed before the influx of new balls.

The introduction and withdrawal of additional balls in this manner is analogous to impressing a difference of electric potential across opposite ends of a metallic conductor. The greater the number of balls introduced per second the faster will be the progressive movement of balls down the length of the court, but at no time will the speed of this progressive movement be comparable in magnitude to the speeds of the individual balls as they are thrown from one player to another.

Metallic conduction, it will be evident, is pure electronic conduction—that is, it is characterized by the absence of transport of matter. In a previous paragraph, the battery or generator in an electric conducting system was likened to a pump. While this analogy is helpful, it must not be carried too far, for there is no transport of matter in the electrical circuit as there is in the hydraulic system. In metallic conduction, the electrons are handed from one atom to another but the atoms do not move.

Propagation of the Effect

The slow progressive motion of the electrons in a metallic conductor may seem incompatible with the speed at which electricity travels through a conductor which, as everybody knows, is extremely rapid. A moment's reflection, however, should make apparent that what is involved here is not the velocity of electrons but the propagation of the effect. In Fig. 6 is depicted a closed pipe line filled with water and containing in one side a rotary pump and in the opposite side a water wheel. It is obvious that when the pump is turned the water wheel will begin to turn almost at the same time, although the transmission of water from the pump to the water wheel may take several minutes or even hours depending upon the length of the system. A similar relation holds in the electric circuit between the progressive motion of the electrons and the velocity of propagation of the effect of the current.

Concluding Remarks on Solid Conduction Theory

Thus we have built up a theory of electric conduction which is based upon the atomic structure of solids and which is capable of explaining many observed phenomena in electric circuits. It must be understood, however, that this is only a theory and, as is always the case with a theory, is open to criticism. Indeed, this theory at the present time is under fire because certain mathematical equations[4] which result from it are not entirely satisfactory; however, it is one of the most satisfactory theories of metallic conduction so far developed and at least enables us to picture what is going on inside of a wire carrying current.

One thing in these explanations of electronic conduction must be directed to the reader's attention though he may have noticed it; that is in regard to the direction of the movement of electrons through the conductor, which is always from the negative to the positive terminal. This is contrary to our usual conception that electricity flows from positive to negative. The discrepancy is due to the fact that the pioneer electrical experimenters, having no real understanding of the nature of electricity in the sense that we know it today, arbitrarily assumed the direction of current to

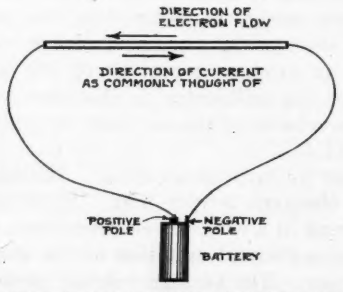


FIG. 7. THE DIRECTION OF THE FLOW OF ELECTRONS IS JUST OPPOSITE TO THAT IN WHICH WE ORDINARILY BELIEVE THE CURRENT IS FLOWING

be from positive to negative. In view of the facts disclosed by the electron theory, this assumption is now known to be contrary to actual facts and while it has made little difference in practical electrical engineering, it now causes considerable misunderstanding in the mind of the student not duly informed. It is an unfortunate condition and because of it we must accustom ourselves to saying one thing and thinking another. When we talk of current flowing from the positive to the negative terminal of a battery or generator, we must think of the electrons (which constitute the current) as moving from the negative to the positive. So we must suffer for the mistakes of our fathers in science.

[4] Matter, Electricity, Energy, by Gerlach and Fuchs, page 146.

Reactive Component in A.C. Circuits

PART VIII. THE USE OF CHARTS AND CURVES IN DETERMINING REQUIRED CORRECTIVE CAPACITY. BY V. E. JOHNSON

IN THE PRECEDING article[1], methods were shown for determining the required corrective capacity in power factor surveys by means of trigonometric tables. Many engineers, however, prefer charts or curves to tables and in this article we shall indicate the use of such charts.

Solution by means of curves and charts is convenient in that it permits of visual interpolation between tabulated values. The accuracy, though somewhat impaired by errors in construction and interpretation, is good enough for most practical purposes, although it is always advisable to check mathematically the final result of computations involving large quantities.

These curves and charts are of two general types: first—those that express graphically the value of trigonometric functions and so merely supply in a different

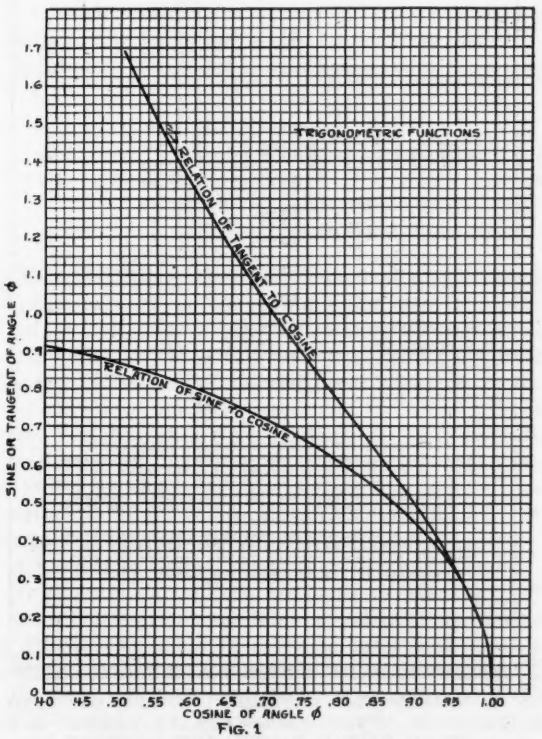


FIG. 1

FIG. 1. CURVES SHOWING TRIGONOMETRIC RELATIONSHIPS

way the data contained in tables, such as the one given in Part VII in the August 1 issue; and second—those which are so arranged as to read the required answer directly, either in per cent or in actual quantities.

The curves in Fig. 1 are of the first class, in that they represent trigonometrical relationships. The lower one gives the relation between the cosine and the sine for various angles; the upper one gives that between the cosine and the tangent. Bearing in mind that the information to be derived from an interpretation of these curves is exactly that given in a table of natural functions, it follows that the calculation necessary is similar to that used in the examples that have preceded.

In this figure, the horizontal scale represents the cosines or power factors pertaining to a certain range of angular displacements. The vertical scale applies to

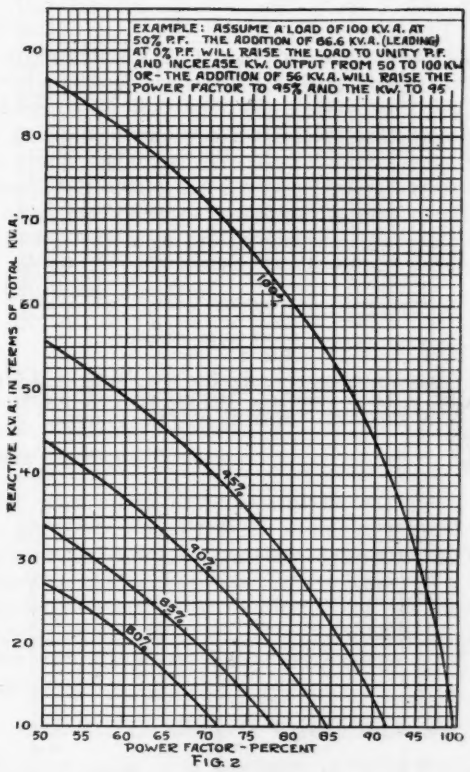

EXAMPLE: ASSUME A LOAD OF 100 KV.A. AT 50% P.F. THE ADDITION OF 86.6 KV.A. (LEADING) AT 0% P.F. WILL RAISE THE LOAD TO UNITY P.F. AND INCREASE KW. OUTPUT FROM 50 TO 100 KW OR - THE ADDITION OF 56 KV.A. WILL RAISE THE POWER FACTOR TO 95% AND THE KW. TO 95
REACTIVE KV.A. IN TERMS OF TOTAL KV.A.
90
80
70
60
50
40
30
20
10
100%
95%
90%
85%
80%
50 55 60 65 70 75 80 85 90 95 100
POWER FACTOR - PERCENT
FIG. 2

FIG. 2. CURVES SHOWING CORRECTIVE CAPACITY (IN TERMS OF ORIGINAL KV.A.) REQUIRED TO RAISE A LOAD FROM A GIVEN POWER FACTOR TO A DESIRED HIGHER POWER FACTOR. THESE ARE BASED UPON A CONSTANT KV.A. OUTPUT

both curves and represents sines and tangents, these in turn corresponding to the reactive components of the load, expressed in percentages of the total kilovolt-amperes and of the kilowatts, respectively.

Example 1. Find the reactive component (in per cent) at 60 per cent power factor.

Solution: At 60 per cent power factor on the horizontal scale, follow a vertical line to a curve intersection, and a horizontal line from this point to the vertical scale. From the lower curve, it is seen that a power factor of 60 per cent corresponds to a reactive component of 80 per cent of the total kv.a.; from the upper curve, it corresponds to reactive component of 1.33 times the true kilowatt load.

[1] Part VII, August 1 issue, page 829.

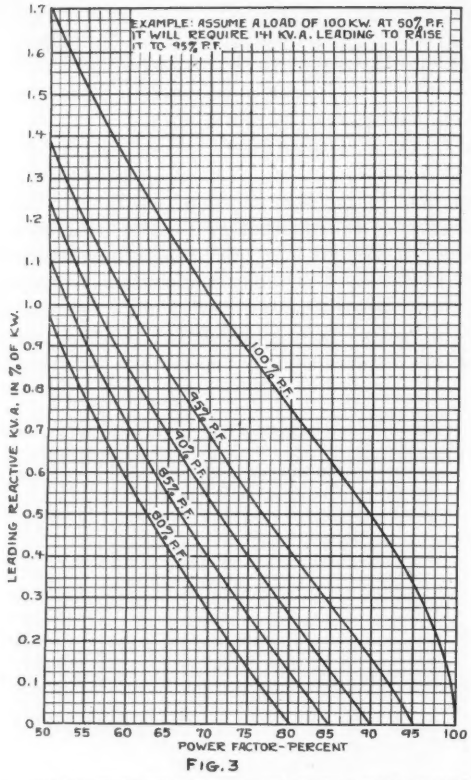
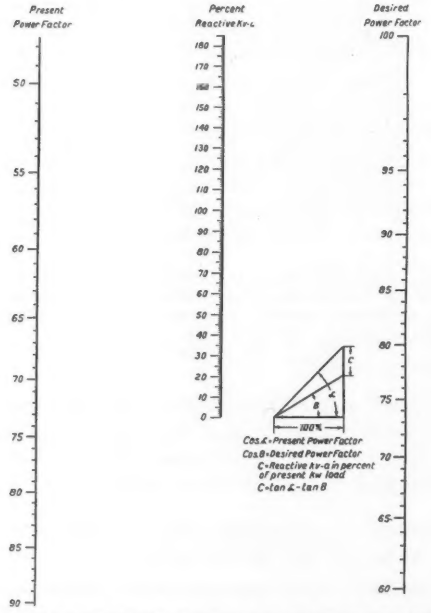

EXAMPLE: ASSUME A LOAD OF 100 KW. AT 50% P.F. IT WILL REQUIRE 141 KV.A. LEADING TO RAISE IT TO 95% P.F.
LEADING REACTIVE KV.A. IN % OF KW.
POWER FACTOR - PERCENT
100% P.F.
95% P.F.
90% P.F.
85% P.F.
80% P.F.

FIG. 3

FIG. 3. CAPACITY IN TERMS OF KW. LOAD REQUIRED TO RAISE A LOAD FROM A GIVEN POWER FACTOR TO A DESIRED HIGHER POWER FACTOR


Present Power Factor
Percent Reactive Kv-a
Desired Power Factor
Cos A = Present Power Factor
Cos B = Desired Power Factor
C = Reactive kv-a in percent of present kw load
C = tan A - tan B

To find the "Per cent Reactive Kv-a." necessary to raise the power factor from "Present Power Factor" to "Desired Power Factor," lay a straight edge across the chart connecting these two values. Read the "Reactive Kv-a." in per cent of the present kilowatt load on the middle scale.

Copyrighted 1921. Westinghouse Electric & Mfg. Co. FIG. 4

FIG. 4. CHART FOR USE IN DETERMINING THE PER CENT REACTIVE KV.A. REQUIRED TO RAISE THE POWER FACTOR TO A DESIRED VALUE

Example 2. With reactive and power components of 100 kv.a. and 200 kw., respectively, to find the power factor.

Solution: With reactive and power components of 100 kv.a. and 200 kw., the ratio of kv.a. to kw. is 0.50. This is the value of the tangent of the angle of displacement; the corresponding cosine is found by following the horizontal line from 0.50 on the vertical scale, to its intersection with the upper curve, and then following a vertical line from this point to the horizontal scale, reading the value of 89 per cent.

Example 3. With a power load of 100 kw. at 80 per cent power factor, the intersection of the vertical 80 per cent line with the upper curve indicates that the reactive component is 75 per cent of 100, or 75 kv.a.

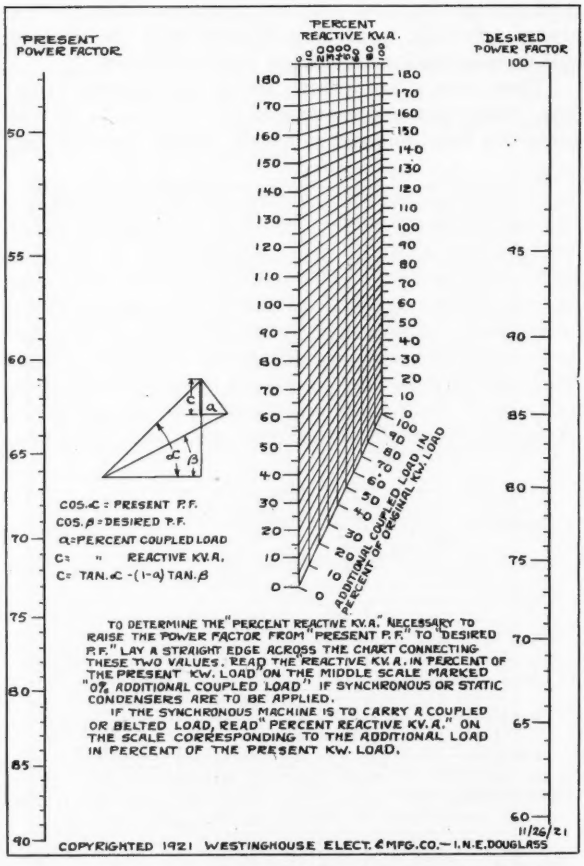

PRESENT POWER FACTOR
PERCENT REACTIVE KV.A.
DESIRED POWER FACTOR
COS. C = PRESENT P.F.
COS. β = DESIRED P.F.
α = PERCENT COUPLED LOAD
C = " REACTIVE KV.A.
C = TAN. C - (1-α) TAN. β
ADDITIONAL COUPLED LOAD IN PERCENT OF ORIGINAL KW. LOAD
TO DETERMINE THE "PERCENT REACTIVE KV.A." NECESSARY TO RAISE THE POWER FACTOR FROM "PRESENT P.F." TO "DESIRED P.F." LAY A STRAIGHT EDGE ACROSS THE CHART CONNECTING THESE TWO VALUES. READ THE REACTIVE KV.A. IN PERCENT OF THE PRESENT KW. LOAD ON THE MIDDLE SCALE MARKED "0% ADDITIONAL COUPLED LOAD" IF SYNCHRONOUS OR STATIC CONDENSERS ARE TO BE APPLIED.
IF THE SYNCHRONOUS MACHINE IS TO CARRY A COUPLED OR BELTED LOAD, READ "PERCENT REACTIVE KV.A." ON THE SCALE CORRESPONDING TO THE ADDITIONAL LOAD IN PERCENT OF THE PRESENT KW. LOAD.
COPYRIGHTED 1921 WESTINGHOUSE ELECT. & MFG. CO. — I.N.E. DOUGLASS
11/26/21

FIG. 5. CHART FOR DETERMINING SIZE OF LOADED SYNCHRONOUS MOTOR NECESSARY TO EFFECT A DESIRED POWER FACTOR IMPROVEMENT

Figure 2 gives a set of curves of the second class, in which the corrective capacity is read directly in per cent of the present kv.a. load. Inasmuch as the final power factor is usually chosen as 80, 85, 90, 95 or 100 per cent, the figure has been prepared to show the per cent of corrective capacity corresponding to an initial load under any condition down to 50 per cent p. f.

Example: To raise a present load of 600 kv.a. at 60 per cent power factor to 90 per cent, requires 38 per cent corrective capacity, or 228 kv.a. The power output increases from 360 kw. to 540 kw.

Figure 3 gives a similar set of curves based upon kilowatt load, instead of kilovolt-amperes.

Example: To raise 350 kw. at 60 per cent power factor to 90 per cent power factor will require 85 per cent corrective capacity, or 306 kv.a.

Figure 4 gives a so-called straight line chart by means of which the corrective capacity in terms of the original kilowatt load can be calculated for any initial and desired condition. A straightedge laid across the three columns indicates by its "crossing points" the relations between the three quantities involved in any power factor problem of this type.

Solution of Problems with Straight Line Charts

Example 1. To determine the corrective capacity required to raise a load of 360 kw. at 60 per cent power factor to 90 per cent power factor, lay the straightedge from 60 in the "Present Power Factor" column to 90 in the "Desired Power Factor" column, and read the per cent corrective kv.a. on the middle scale—in this case 85 per cent. The reactive kv.a. required will therefore be $0.85 \times 360 = 306$.

Example 2. To determine the improvement in power factor which results from adding 100 kv.a. at zero p. f. leading, to a present load of 400 kw. at 70 per cent p. f.

Solution: The ratio of corrective kilovolt-amperes to present kilowatt load is $100 \div 400$, or 0.25. The straightedge is laid from 70 in column 1 to 25 in column 2. It will intersect column 3 at 79 per cent power factor—the characteristic after the improvement.

Figure 5 shows another straight line chart prepared by the Westinghouse Electric & Mfg. Co. for determining the size of a loaded synchronous motor necessary to effect a desired improvement in power factor. This is constructed in a manner similar to the chart in Fig. 4 and is for zero coupled load exactly the same.

Example: To raise a load of 600 kv.a. at 60 per cent p. f. (360 kw.) to 90 per cent power factor and at the same time carry a coupled load of 90 kw. (including losses), will require 0.72×360, or 260 reactive kilovolt-amperes. The motor will be rated at 276 kv.a. input, and will operate at 32.5 per cent power factor leading.

The four curves given here will be sufficient to permit of the solution of the majority of problems that are met with. There are many others, variously arranged, which will give the same information, and some that take into consideration other factors that occasionally enter into a comprehensive power factor survey. Many of them, in striving for accuracy, become cumbersome and often confusing; it is ordinarily easier and more direct to fall back on the fundamental principle of the load triangle in cases that are not covered by the curves that have been discussed.

Car Pullers for Power Plants

Simplicity, Ruggedness and Low Operating Cost Make This Time Saver a Necessity in Many Plants

BECAUSE COAL and oil, important and necessary raw products of the power plant, are usually received by rail, the spotting or locating of cars at the proper point for unloading is an important duty of the engineer. If the plant is small, receiving but one car at a time, the problem is simple but if fuel is received several carloads at a time, spotting the cars over the track hopper or unloading line means either an excessive switching charge or interrupting the work in other departments to get sufficient men to move the car in a reasonable length of time.

A number of simple, rugged devices known variously as car spotters, car pullers, car hauls, capstans, gypseys or drum hoists are on the market and their use enables one man to spot a car in a few minutes with no more physical exertion than throwing a switch and hauling in the slack of the towing line. Car spotters of this kind are made for motor, gasoline engine, steam engine or belt drive although the motor drive is the handiest and most common for power plant service.

Several representative types of these machines are shown in Fig. 1. With the exception of Fig. 1-A, arranged for belt drive, all of those illustrated are electric motor driven. For ordinary pulling requirements, the capstan or niggerhead type illustrated by A, B, C, D, E, F, G and H is commonly used. Usually the motor is completely housed or fully enclosed, making the unit thoroughly weatherproof. Except in the large sizes, they are so compact that they can be mounted on a warehouse truck and moved from point to point as occasion demands.

For long heavy hauls and grade work, the drum type, of which Fig. 1-I is an example, is used. The particular one shown is a two-drum type with the drums loose on the shaft. Between the two drums is a clutch which can be engaged with either drum, the other one remaining free on the shaft. This type hoist is adapted for moderate double track machine haulage or tail rope haulage.

Cars Can Be Moved in Either Direction

In some yards, it is necessary to move cars either way on one track or in one direction on one track and in the opposite direction on the next parallel track. For this purpose, an endless rope running around various sheaves, as shown in Fig. 2-A, can be installed.

Instead of a drum, a spool of the type shown in Fig. 1-J, with four or five turns of rope, is used. A counterweight is necessary to keep the rope tight and in uniform tension on both sides of the car puller. The particular machine shown has a single line rope pull of 12,000 lb.

With the arrangement of loop, shown in Fig. 2-B, cars may be moved in either direction on any one of three tracks. The automatic gravity takeup in the structural steel tower maintains an even tension in the slack side of the haulage rope regardless of the direction of travel.

The counterweight is hung in a bight of a separate rope, the ends of which are attached to floating sheave blocks in bights of the two sides of the haulage loop which is wrapped around the two drums of the engine

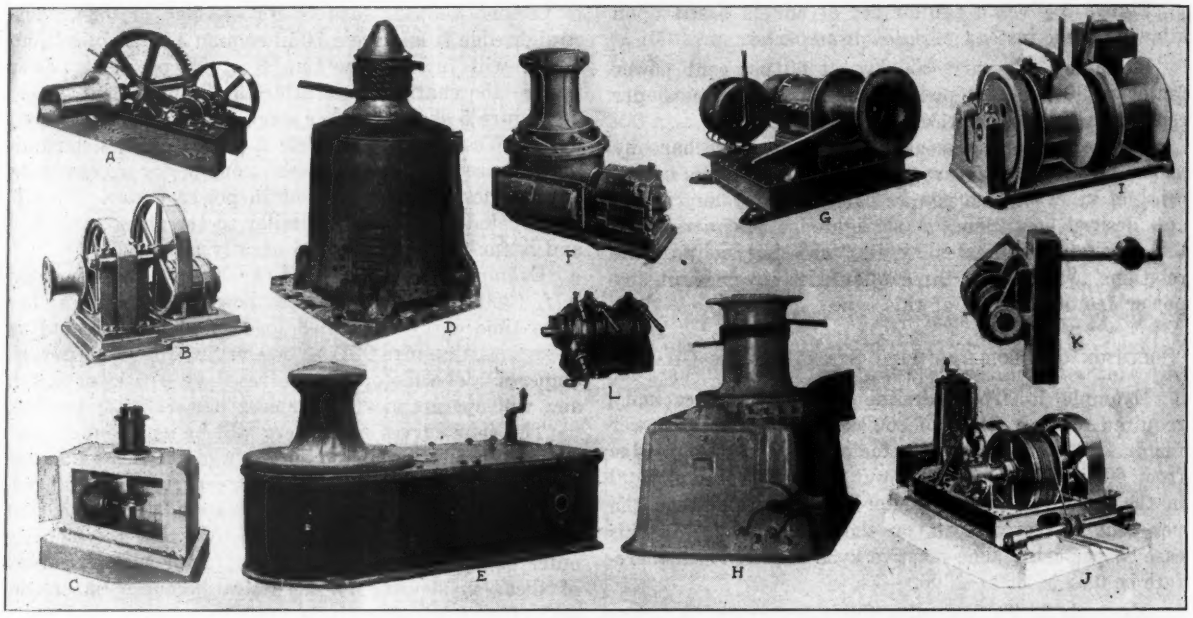


FIG. 1. SEVERAL TYPES OF CAR PULLERS SHOWING DIFFERENCES IN DESIGN

shown in the house. The cable grip is hand operated and is attached to a pulley rope about 25 ft. long, provided with a hook for attaching to the car.

Another machine closely allied to car pullers and known as the car retarder is illustrated in Fig. 1-K. In this case, the cars to be loaded are placed on an inclined track above the tipple and their movement down the incline controlled by the retarder. The rope from this car passes several times around the drum and the slack is taken up by the counterweight. A brakeband normally held tight by a counterweight keeps the drum from turning until the weight is lifted, releasing the drum and allowing the car to go down the hill by gravity.

Control of Car Puller Motors Is Simple

Some of the machines have a hand control and some a foot control. As a rule, the motors are small and are full voltage starting under no load so that a simple switch only is necessary. Some of the large and more complicated machines, however, use variable speed or reversing motors necessitating the use of additional control equipment.

As a rule, fairly straight and level track is encountered for power plant service and no provision need be made to hold the car on the grade. A ratchet and pawl can, however, usually be furnished on the underside of the capstan so that a car can be held on an incline when the power is off. A capstan of this type is shown in Fig. 1-F. Solenoid brakes are sometimes added to the motor, the brake band being arranged to bear on a pulley attached to the outboard end of the motor shaft.

Range of a car puller is limited only by the length of the rope and a coverage of 300 ft. of track on each side of the puller is not uncommon. Many times, in a small industrial plant, a car puller mounted on wheels as in Fig. 3 can be of service all over the plant. In addition to moving cars, it can be used for hoisting or dragging, assisting trucks, operating drag lines and scrapers, moving merchandise and machinery or as a light hoist.

About 15 Lb. Rope Pull Required for Each Ton

Small pullers designed to handle one or two cars usually have about a 5-hp. motor, a rope speed of

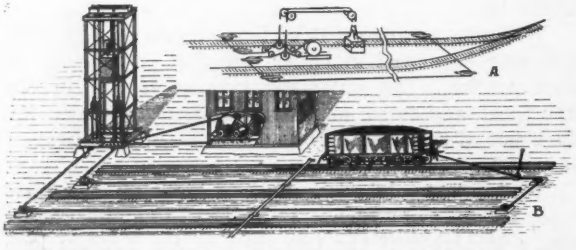


FIG. 2. ARRANGEMENT USED WHEN CARS MUST BE HANDLED IN BOTH DIRECTIONS

FIG. 3. PORTABLE UNITS HAVE MANY USES IN A SMALL PLANT

from 35 to 50 ft. per min. and a rope pull of from 2000 to 3000 lb. A representative machine with a 5-hp., 1200-r.p.m. motor has a rope pull of 2650 lb. at a speed of 44 ft. per min. Allowing 15 lb. per ton of weight of freight car and contents, this puller will handle two loaded cars (75 t. each total weight of car and contents) or seven empty cars (25 t. each) on a straight level track. One of the larger types with three speeds and driven by a 40-hp. motor is rated as follows: 30 ft. per min. 30,000 lb. rope pull, 90 ft. per min. 10,000 lb. rope pull and 200 ft. per min. 1000 lb. rope pull.

Motors, being small and starting under no load, can be started directly across the line and require only a simple starter or switch. The typical efficiency of a 5-hp. motor for this service is: 87, 86 and 85 per cent

TABLE OF VALUES TO USE WITH FIG. 4

Dimension "A" in inches	Degree of Curve	Radius of Curve in feet
3½	5	1146
6½	10	573
9¾	15	383
13	20	287
16½	25	231
20	30	193
23½	35	166
27	40	143

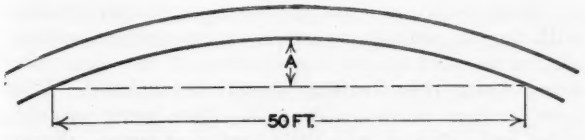


FIG. 4. METHOD OF MEASURING TO DETERMINE THE CURVATURE OF THE TRACK

at 5, 3.75 and 2.5 hp. respectively, the corresponding power factors being 89, 87 and 80.

One of the outstanding advantages of the car puller is the simplicity of operation. It is only necessary to hook one end of the rope to the car, wrap the other end loosely around the capstan two or three times, start the motor and pull on the loose end sufficiently to cause the rope to grip the capstan. Pull can be applied in any direction and, with a suitable arrangement of sheaves, around corners and other obstructions. The use of sheaves for indirect pulls is well illustrated in Fig. 3.

EFFECT OF GRADES AND CURVES ON CAR PULLER CAPACITY

If grades or curves have to be considered, the capacity of the puller measured in carloads decreases. To the 15 lb. per ton friction load allowed for straight level track an additional allowance of 20 lb. per t. must be made for each per cent of grade and 1 lb. pull per ton for each degree of curvature of the track. Thus a car puller which could handle 150 t. on a level track could handle only about 41 t. on a 2 per cent grade. The per cent of a railroad grade is the number of feet of vertical rise in each 100 ft. of length.

Curvature of the track can be calculated by means of Fig. 4 and the accompanying table. To determine this value, it is necessary to stretch a 50-ft. tape across

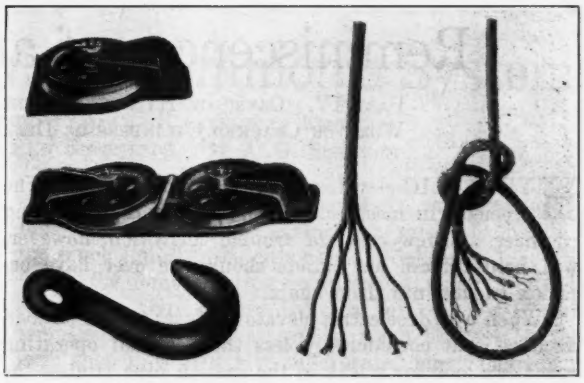


FIG. 5. SEVERAL ACCESSORIES FOR CAR PULLERS: 5-A, SINGLE SHEAVE; 5-B, DOUBLE SHEAVE; 5-C, HOOK, AND 5-D AND 5-E, A SPECIAL MARLINE COVERED WIRE ROPE WHICH WILL NOT WEAR GROOVES IN THE CAPSTAN

the curve as shown in Fig. 4 and measure the distance A at the center. The degree of curvature can then be read from the table opposite the proper value of A.

Wire rope should not be used on capstans because of the tendency to wear grooves in the metal, the difficulty of handling the slack end and the danger of scratches and infection to the operator's hands. Manila or Durable rope is preferable. Durable rope is a marline covered wire rope of the type shown in Fig. 5-D and 5-E. For a pull of 3000 lb., 1 or 1½-in. Manila or ¾-in. Durable rope is recommended and for a pull of 6500, 1½ or 1⅝ Manila or ⅞-in. Durable is recommended by one manufacturer. Figures 5-A and 5-B show typical single and double sheaves and 5-C one type of hook for use with ropes.

Some manufacturers recommend, as the most convenient and serviceable, a Manila or Durable rope with 6 or 8 ft. of chain preceding the hook. The hook at the end of the chain can be attached to different parts of the car much more easily than if the hook is fastened directly to the rope. A well arranged industrial power plant car puller installation is shown in Fig. 6. Installed in this manner, opposite or nearly opposite the track hopper, the car puller can be used to move cars in either direction over the hopper without resort to an indirect pull.

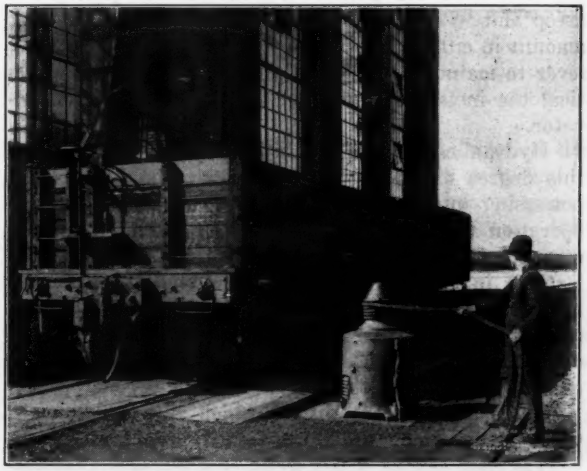


FIG. 6. INDUSTRIAL POWER PLANTS FIND CAR PULLERS A GOOD INVESTMENT

Reminiscences of an Elevator Inspector*

PART IV. CREEP OF HYDRAULIC ELEVATORS CAUSED BY LEAKY CUP LEATHERS, WORN OR CRACKED CYLINDERS OR DEFECTIVE PILOT VALVE. BY S. H. SAMUELS

HYDRAULIC elevators also have their troubles. The remedy in most cases is obvious to the operating engineer. A few cases of trouble correction, however, will help refresh our minds should we ever have occasion to run into them again.

When a hydroelectric elevator refuses to lift its load or lifts it at considerably less than normal operating speed, we look for a leak in the suction pipe (unless the plunger packing gland has just been tightened up too much). The position of loss of suction is easily located by stopping the elevator and noting where the water is running out of the suction pipe or perhaps out of the pump packing gland.

Many times the elbow connection where the discharge pipe enters the plunger and comes from the pump will break off from repeated water hammer caused by stopping the elevator quickly when loaded, unless this elbow is firmly imbedded in a heavy block of concrete to take up and dissipate the stresses set up at this weak place in the piping.

Hydroair elevators operate by air pressure forcing water into the plunger cylinder. There are two tanks, the one nearest the elevator containing water and the other tank containing compressed air. A hydroair elevator becomes dangerous when operating on air alone or low water level for when the tiller rope is moved to operate the valves, the car rises or descends at dangerous speed. For this reason, it is imperative to keep the water gage glass clean and free from rust deposit in order that proper water level may be maintained in the water tank. Soap solution mixed with the water to give a milky solution will materially aid operation in reducing friction, preventing corrosion and keeping the gage glass clean.

ELIMINATION OF CREEP

Creep of hydraulic elevators can be entirely eliminated under ideal conditions and can be greatly minimized in other cases. A hydraulic car should stand at the floor level for at least 5 min. without perceptible creep and without the valve "cracked" open the least amount in either direction (by movement of car control lever to maintain this position) in order to make practical the installation of interlocks on this type of elevator.

Hydraulic elevators should be maintained in at least this degree of no-creep condition on installations not possessing interlocks in order to secure maximum safe operation under these conditions. It is the engineer's duty to give immediate attention to replacing worn cup leathers in either the main or pilot valves when they begin to go bad. If cup leathers are wearing out too quickly or are getting cut or worn under peculiar conditions, no effort should be spared to correct this trouble or to prevent it from getting worse.

There are other conditions which will make an elevator creep which are not so easily repaired by the engineer. Nevertheless, he should do all in his power to overcome as much of this trouble as is possible. An elevator might be caused to creep on account of a worn cylinder which may have only a single zone of wear. On one installation this zone of cylinder wear fortunately happened to be at position where the elevator would appreciably creep when at the main floor landing. The trouble was remedied by raising the bumpers so that the car would land on them at the main floor, thus eliminating the basement landing.

DEFECTIVE CUP LEATHER CAUSES CREEP

Another case of bad creep directly caused by one of the cup leathers on the main valve becoming cut and torn on one side after a few trips of stopping and starting the car. This cutting of the cup leather was caused by a longitudinally cracked liner in the main valve in one instance, while in another instance the brass liner was distorted from being pressed into the valve body too hard either by being made too tight a fit or started crooked. In the latter case, the drilled port holes were responsible for the cutting of cup leathers.

When a hydraulic car cannot be kept from creeping with the car controller centered in its proper quadrant slot on account of the cup leathers of the pilot valve being worn, these leathers should be replaced. With new leathers in the pilot valve after being properly fitted and softened by a little service operation, the car lever should be adjusted to hold the car in a "no-creep" condition when placed in the center of its quadrant after being slightly moved in the opposite to running position in order to take up the small amount of "lost motion." These adjustments should be maintained for some time or until the leathers become worn.

If the engineer has trouble with his leathers wearing too rapidly, after these adjustments, and his elevators still creep and it is necessary to "crack the valve open" by movement of the control lever to either side of the neutral position, it will be well for him to investigate the plug type valve perfected by the chief engineer of the Mills Building, San Francisco. The plug type valve is a pilot valve with a loose fitting plug which allows equal quantities of water to escape in both directions at the same time by virtue of its loose fit. The elevators in the Mills Building will stand all night on any floor of the building where they are left with the control lever locked in the neutral position with hardly a half inch change in position.

In one installation, all adjustments had been properly made and yet when the car was discharging a full load of passengers it crept so badly that it was necessary to close the hoistway door three different times and bring the car to the floor again before the last few passengers were discharged. The installation of the plug type valve relieved all of this engineer's worries and permitted the installation of effective interlocks for this elevator.

*The other articles of this series, of which this is the concluding number, appeared in the May 15, July 1 and August 1 issues.

Temperatures and Pressures in Ammonia Systems

PRACTICAL INFORMATION ON TEMPERATURE-PRESSURE RELATIONS IN REFRIGERATING SYSTEMS OF INTEREST TO OPERATING ENGINEERS. BY A. G. SOLOMON

IN THE JUNE 15 issue of Power Plant Engineering, there appeared a short discussion of Temperatures in Refrigerating Systems. It was this article that suggested the ideas for the one here presented.

In measuring temperatures, a thermometer placed in the ammonia discharge line of an ammonia compressor is usually located close to the compressor. This thermometer will show the temperature of the ammonia gas leaving the compressor.

Temperature readings taken at this point are of very little value to the engineer in the operation of the plant.

Ammonia gas leaving the compressor must not be confused with the ammonia vapor entering the compressor or with the ammonia that enters the condenser. The relation between pressure and temperature of ammonia exists only when the ammonia is in a saturated state.

Liquid ammonia can have many different temperatures while the pressure remains the same. Ammonia gas or vapor not in contact with liquid can have a wide range of temperature yet the pressure remains constant.

Saturated ammonia vapor will always have fixed or certain temperatures for the corresponding pressures.

TABLES GIVE PROPERTIES OF AMMONIA

If we study the ammonia tables, we shall see at a glance that there are more than one set of tables. First there is the table that deals with the "Properties of Saturated Ammonia." This is the table that we, as refrigerating engineers, must study and partly memorize.

Next comes the table of "Properties of Liquid Ammonia." This table gives a temperature-pressure relation that is the same as the saturated vapor relation. But this relation exists only under some conditions. We know that the temperature-pressure relation of the liquid can be changed easily. Simply pre-cool the liquid ammonia between the condenser and the expansion valve and we have a temperature of liquid ammonia many degrees lower than that shown in the table to correspond with the pressure.

Or, if we allow an uncovered liquid line to pass through a hot engine room, the temperature of the liquid reaching the expansion valve will be some degrees warmer than the temperature of saturated ammonia at the condenser pressure carried. This shows that we must guard against heat entering the liquid at any place between the condenser and the expansion valve. (The liquid receiver is included in this, for heat will surely pass through the walls of the receiver if the surrounding atmosphere is hot.)

We have also the table "Properties of Superheated Ammonia Vapor." In this table the temperature-pressure relation does not exist.

In regard to the temperature of the ammonia gas leaving the compressor, this may be very near to that which corresponds to the saturated temperature; however, such cases will be exceedingly rare and not of long duration, for the compressor would be handling too much liquid to be either safe or efficient.

In the double acting compressors, using liquid injection to help remove the heat of compression, the temperature of the discharge gas can be kept low but even then it is generally superheated many degrees.

FACTORS AFFECTING DEGREE OF SUPERHEAT

In the operation of the vertical single acting type compressor, the degree of superheat will depend on many things. First the temperature of the ammonia entering the compressor must be considered. This temperature can be that of saturated vapor at the pressure

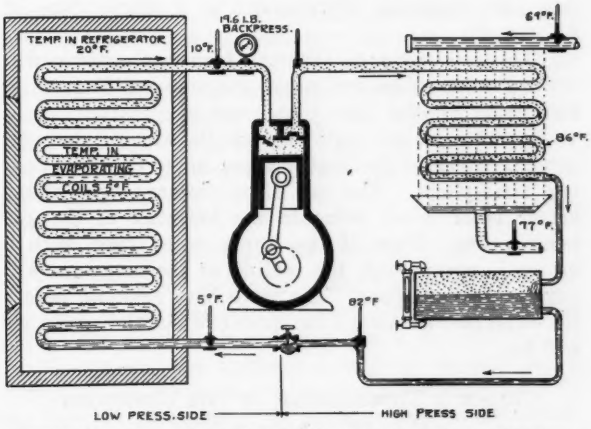


DIAGRAM OF THE COMPRESSION SYSTEM SHOWING TYPICAL TEMPERATURES

carried in the evaporating coils. Or it can be 10, 20 or 30 deg. higher. This condition will depend on the travel of the vapor after it leaves the evaporating coils. A long uninsulated suction line will cause superheating.

ARRANGEMENT OF PIPING IN FORE COOLER AFFECTS AMMONIA TEMPERATURE

In ice plants, the arrangement of the piping for the fore-cooling of the can filling water will affect the temperature of the ammonia.

A fore-cooler can be so designed and installed that the ammonia will be heated as much as 30 or 40 deg. in its travel through the coils; and at times a large amount of warm water can be circulated through the fore-cooler and this can easily cause a superheat of several degrees.

No set rules can be given for the proper temperature of the ammonia entering or leaving an ammonia compressor. Of course we can give temperatures and pressures that would allow the compressor to do the greatest amount of work according to theory. But this may not be the best operating condition when the entire plant is considered.

Looking into the conditions that affect ammonia temperatures in the compressor itself, we find that it is

about impossible to pass saturated vapor through the suction valves. Any particles or drops of liquid that come in contact with the metal of the valves, piston, piston rod or cylinder will at once become superheated vapor. All this metal is really hot when compared with the temperature of saturated ammonia vapor at the suction pressure carried.

Next comes the work performed on the ammonia during compression. The water circulated through the water jackets removes some of the heat of compression and helps keep the discharge temperature down. The hot gas now passes through the discharge valves which are hot. The thermometer in the discharge line close to the compressor can show a temperature anywhere from 100 to 300 deg., depending on operating conditions, regardless of the condenser pressure.

The critical temperature of ammonia gas is 273.2 deg. F. At this temperature, the ammonia cannot be changed back to the liquid state at any pressure that we have in the operation of ammonia compression machines. This statement need not cause the least worry to the refrigerating engineer any more than the fact that pure ammonia disintegrates at a temperature of 900 deg. F.

The only danger is that the high temperature will decompose ammonia and cause non-condensable gases to form more rapidly than with lower temperature.

Superheated gas now goes on its way to the condenser. Much of the heat is given up to the surrounding atmosphere. The use of a discharge gas water heater is of much value in the lowering of the gas temperature. Even if the warm water from such a device is not needed, the cooling of the ammonia will pay the money spent. The more heat removed before the condenser is reached the more efficient the condenser will be.

Place a Thermometer at the Condenser

At the condenser is a good place to put a thermometer, for this will show very nearly the proper temperature of the ammonia gas as it enters the condenser coils. This is the temperature of the gas that has to be liquefied and cooled by the water circulating through or over the condenser. If a discharge gas water heater is in use, the temperature of the ammonia entering the condenser can easily be that of saturated ammonia vapor at the pressure carried.

The temperature at which the ammonia begins to liquefy at the condenser pressure carried will exist in the upper part of the condenser. The temperature in the lower part of the condenser will be from 5 to 8 deg. higher than the temperature of the circulating water leaving the condenser.

From 3 to 10 deg. temperature rise will be found between the water coming on the condenser and that leaving. This difference will be affected by the amount of water, temperature of water coming on, type of condenser, load on compressor and the weather conditions.

At 185 lb. condenser pressure, the liquefying temperature is 96 deg. F. That means that the superheat has been removed from the discharge gas and the ammonia has assumed a saturated state. This temperature exists while liquefaction is taking place.

After the ammonia becomes liquid the circulating water removes more of the heat. With 69 deg. water going on the condenser it is almost impossible to have a liquid ammonia temperature of 71 deg. at the liquid outlet. This may be done with a double pipe or multipass condenser but never with other type condensers. When the water and ammonia temperatures are found within 2 or 3 deg. of each other, it is a good idea to check up on the thermometers and see if they are correct.

Factors Affecting Condenser Pressure

With sufficient water leaving the condenser at a temperature of 77 deg. it is possible to carry a condenser pressure of 135 to 140 lb. To do this, however, the system must be absolutely free of all non-condensable gases and other impurities. Also a heavy charge of ammonia must be in the system so that there will be a liquid seal at the outlet of the ammonia liquid receiver at all times and this seal must have a depth of not less than 4 in.

It will require nearly ideal operating conditions to hold the condenser pressure below 165 lb. The temperature of the brine or cold storage rooms must also be kept practically constant to insure the ideal operating conditions.

Thermometers for the suction side of the machine will give the best obtainable information if they are located at points where the ammonia vapor enters the main suction header from different evaporators. If there are two or three ice tanks and a few cold storage rooms having direct expansion piping, the proper place for thermometers is at the point where the suction line comes out of each ice tank and from each cold storage room.

With evaporating coils in several different places the thermometer on the main suction header would be misleading. The ammonia could come from one set of coils in so heavily saturated a state as to give a saturated ammonia temperature at the machine and at the same time some of the coils would be sending ammonia to the suction header that had a superheat of 10 or 15 deg.

This much written on the practical use of thermometers and the study of temperature-pressure relations should be a starting point for further discussion. The subject is easily understood if a proper beginning is made.

New ways to solicit power from his surroundings usually mean new eras in man's life, new marks; and with steam engines to bring the power of heated gas to industry this latest of new ages began. That was in the 18th century, 500 yr. after the boom and flare of gunpowder had begun to stir the western peoples. But steam gas was industrial in effect, whereas the gas of gunpowder had been political and military; men learned that steam could lift and carry and construct better than men's backs or horses' legs or the sails of ships. Modern industrialism came and exploitation of the coal resources of the world, only when men had learned steam's lesson. It was the old tale of gunpowder reapplied: they could do it better with gas.—Baker Brownell.

For the safety of users, selection of tools for all classes of work should be such that an extremely high grade of workmanship and material will be incorporated in their manufacture.—N. E. L. A.

Employment Contract Rights and Liabilities

DEFINITION OF AN EMPLOYMENT CONTRACT AND DISCUSSION OF RIGHTS AND LIABILITIES OF EMPLOYER AND EMPLOYE INVOLVED. BY LEO T. PARKER*

BROADLY SPEAKING, a valid contract for employment represents any legal transaction between two or more persons as a result of which both of the parties assume obligations to perform certain acts and it is important to know that a verbal contract of employment is as effective as one written. There is the important difference, however, between a verbal and a written contract that testimony must be used to prove the content to a verbal contract, whereas a written contract speaks for itself and no verbal testimony is permitted by the courts to vary the written agreement.

Moreover, under certain circumstances, a contract may be implied by the court. Although no verbal or written agreement exists between an employer and his employe, the court may decide that the contractual obligations were assumed.

CONTRACT DEFINED

For instance, one court ruled as follows: "A contract is defined to be an agreement between two or more persons, for a good and sufficient consideration, to do or not to do a thing. It is unnecessary that a contract be in writing and it may be either expressed or implied. An expressed contract is one where the terms of the agreement are stated definitely and an implied contract is where the law is presumed on the part of the party benefited."

Strictly speaking, an agreement of employment is valid if the duration of the contract, compensation to the employe and his duties are clearly set forth.

In some cases, courts have supplied missing words to contracts and otherwise construed the intended meaning of the parties.

For example, a firm wrote and offered a person a position at a specified amount for each day's work and then said, "We *can* promise to pay you when you are not working." In construing this contract, the court supplied the word "not" before the word "promise", because other parts of the contract indicated that the employer did not intend to agree to pay the employe for the days he *did not* work.

DAMAGES FOR BREACH OF CONTRACT

It is well settled that the terms of a valid verbal or written contract of employment must be carefully fulfilled by both the employer and employe, otherwise the one who breaches the contract is liable in damages.

For illustration, it was disclosed that a contract contained the clause as follows: "This is to certify that the undersigned, Bridgeport & Co., will guarantee Louis T. Meagher a steady position for a term of 3 yr., provided Bridgeport & Co. is in existence, at a salary of not less than $22.50 per week, payable weekly, said Louis T. Meagher to give his entire time and attention to the services of Bridgeport & Co."

When the employe was discharged without cause, he instituted suit against his employer for damages. The employer attempted to avoid liability on the contract because it did not distinctly obligate the employe to remain in the employment for 3 yr. but the court held the employer liable in damages and said: "Appellee (employe) in undertaking to give his entire time and attention to the services of the appellant (employer), clearly obliged himself to render this service for the term of 3 yr. at the price stipulated in the contract. He was as much bound by the terms of the contract, to render service for the time specified, as appellant (employer) was to employ him for that time. The contract imposed upon each of the parties mutual and reciprocal obligations, and a breach of terms by either gave to the other a cause of action."

Generally, the amount of damages for which an employer is liable for wrongfully discharging an employe is based upon the pecuniary loss to the latter.

One court held that: "The well established modern doctrine is, that if one employed for a specified term is wrongfully discharged before the expiration of the term, the employer is bound to pay him such damages, not to exceed full wages for the whole time specified in the contract."

DAMAGES BASED ON ACTUAL LOSS

In holding an employer liable for wrongfully discharging an employe who had been hired for a specified period, the court explained that:

"1. An employe discharged may sue at once for a breach of the contract and recover his damages up to the time of suit brought. 2. He may wait to the end of the contract period and then sue for the breach, when he may recover his entire damages. 3. He may treat the contract as broken and sue immediately for the services performed, in which case he can recover for the time actually served."

Unless convincing testimony is introduced, to prove that an employe diligently endeavored to obtain employment after his discharge and was unable to do so, he is not permitted to recover damages equal to the amount of the unearned salary. He cannot sit down with folded hands and insist upon payment of his wages for the balance of the contract period. His right to recover damages from the employer is limited to the actual loss he sustained, which is the amount he would have received if he had been permitted to complete his contract, less what he has earned in the meantime, or what he might have earned by due diligence in seeking employment.

It is well settled that, although an employe is hired for a stipulated period, the employer is privileged to discharge him for default in duty or any other act by which the employer or his business is jeopardized or injured. In the words of one court: "To justify the discharge of an employe before the expiration of the term of employment, it is sufficient for the employer to show that the employe was guilty of a default in duty

*Attorney at Law, Cincinnati, Ohio.

whose natural tendency was to injure his business and actual injury thereto need not be shown."

Services Must Be Satisfactory

Contracts of this general character, known as satisfaction contracts, in which one party agrees to perform his part to the satisfaction of the opposite party, are frequent sources of litigation, because of the disappointments such contracts often bring to the party who has taken the chance of performing work satisfactorily and the difficulty of ascertaining what really constitutes satisfaction. Such contracts are enforcible however, to the extent that the intent of the contracting parties can be ascertained.

In one instance, a contract of employment contained the following clause: "We reserve the right to terminate your employment at any time during the year for conduct unsatisfactory to the officers of the company, or for other cause."

As the company discharged the employe without giving reason for doing so, the latter filed suit for damages, contending that the discharge was not in accordance with the above clause, since the employer had failed to explain that his services were unsatisfactory. The court held the employer not liable and in effect said that, when a contract of employment contains a provision that the employe is subject to discharge for conduct unsatisfactory, the law implies that his services are not satisfactory, where the employer discharges him for good reasons.

Generally the courts hold that the employer is the sole judge as to whether or not the employe is satisfactory. Moreover, the employe cannot recover on a suit instituted because the employer afterward hired another inexperienced employe.

On the other hand, where a contract of employment provides that an employe may be discharged if his services prove dissatisfactory to his employer, the latter is liable in damages if he discharges the employe on mere pretext that such services are not satisfactory.

Moreover, an employer cannot avoid liability for wrongful discharge, although he is honestly dissatisfied with his employe's services, unless the contract distinctly specifies that the employer may discharge the employe, if his services are dissatisfactory.

Liability of Employer

On a contract for one year, which contained the clause: "The party of the second part (employe) is desirous of obtaining and filling such position to the satisfaction of the parties of the first part (employer)," the employe sued the employer for damages, when he was discharged on the excuse that his services were unsatisfactory. The court said: "The only point involved is whether the contract is to be read as one entitling the defendants (employers) to discharge their employe on the ground that they were dissatisfied with his work. I do not find that a mere casual recital of an obvious state of mind of the employe converts a contract of absolute employment for a definite time into one dependent upon the satisfaction of the employer with the work of the employe."

In many instances, contracts of employment have been held invalid for want of definiteness. On a contract of employment whereby the employer agreed to furnish the employe steady and permanent employment until the employer's factory was put in operation, the employe claimed damages on the contract upon being discharged. The court held that the contract was indefinite and invalid, terminable at will, saying: "That no time is fixed in which appellant's factory was to be completed, or when it was to commence operations: That after said factory should commence operations, there is no averment as to the length of time he should remain in the service of appellant, or how long the factory was to be operated."

Sometimes litigation develops where the contract merely specifies that the employment is permanent. It is important to know that generally, where an employer agrees to give an employe a permanent position, the former is privileged to discharge the employe at any time he desires to do so.

"A contract for 'permanent' employment is construed to mean nothing more than that the employment is to continue indefinitely and until one or the other of the parties desires, for some good reason, to sever the relation."

Employment for Injuries Sustained

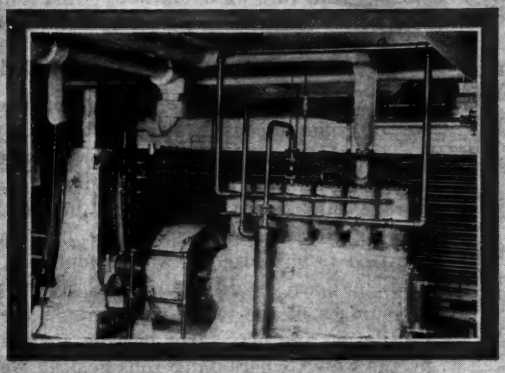
Where an employer agrees to employ an injured employe permanently at a stipulated wage to compensate for an injury, the courts have consistently held that the former is bound to employ and pay the agreed salary indefinitely as long as the business is conducted and until the employe fully recovers his health.

Sometimes, contracts of this kind specify that, in consideration of the employer being relieved from payment of damages for injuries sustained by an employe, the former agrees to employ the injured employe for his life at an agreed salary. Generally speaking, these contracts are valid and enforcible.

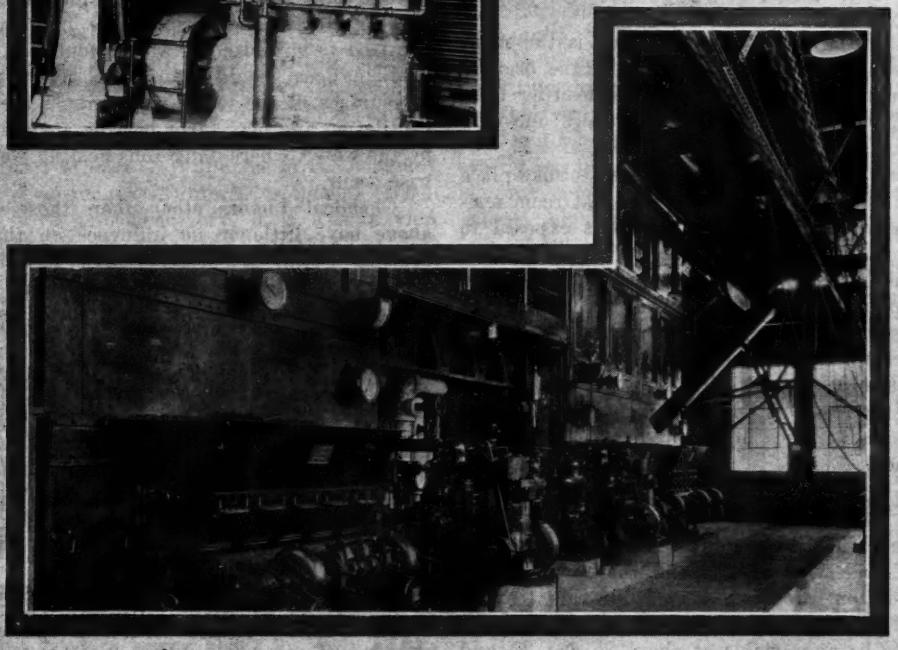
It was disclosed that to compensate an employe, who had one hand severed while attending to his regular duties, the employer contracted to hire the workman at $25 per week during the balance of his life. After paying the employe for 12 yr. the employer attempted to discharge him, contending that the contract was invalid. The court held the contract valid, and said: "It is well settled that the law favors compromises, when made in good faith, whereby disputed claims are settled. Especially is this true when related to family controversies and a promise, when thus made, in extinguishment of a doubtful claim, furnishes sufficient consideration to support a valid contract. While it is unnecessary that the contention which forms the basis of such a compromise shall be meritorious in order to support the promise, yet it is essential, in order to furnish a consideration therefor, that the contention be made in good faith and be honestly believed in."

Boilers for high pressures account for 85 to 90 per cent of the extra cost of such plants, according to statement of K. Baumann before the Institution of Civil Engineers. Turbine and condenser are responsible for 5 per cent of the cost increase, while piping pumps and auxiliaries come in for 5 to 10 per cent.

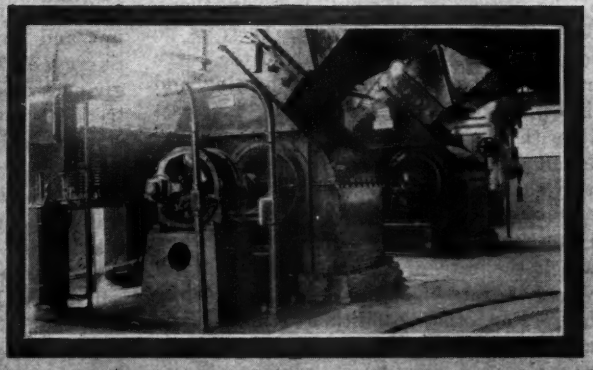
New Boiler House for the Herman Kiefer Hospital, Detroit



Plant supplying steam and refrigeration for 500-bed municipal hospital is conveniently and attractively arranged.



Steam at 125 lb. is made by three 400-hp. stoker fired boilers. Fans and service pumps in basement. Vertical steam engine drives 6-cylinder 25-t. ammonia compressor. Plant designed by Albert Kahn, Inc., erected by A. W. Kutsche & Co., operated by Chief Engineer Charles Butzky.



Spontaneous Heating of Coal in Storage

GENERAL REVIEW of the results of chemical and physical research relative to the causes and prevention of the spontaneous heating of coal in storage has been published by the United States Bureau of Mines, Department of Commerce, as Technical Paper 409.

All coals but anthracite undergo some spontaneous heating, state Joseph D. Davis and D. A. Reynolds, the authors. The liability to self-heating is greatest among coals of lowest rank. One must therefore use greater care in storing a subbituminous coal than in storing a high-rank bituminous coking coal. More pains should be taken to prevent segregation of fine coal in the storage pile, and foreign matter should be excluded more carefully.

Oxidation of the coal substance itself is the main cause of spontaneous combustion; some of the organic constituents may contribute more to the heating than others, but it has not been shown that any one constituent exerts a preponderant influence.

Spontaneous heating may be considered to take place in two stages. The first stage is operative at room temperature as soon as freshly broken coal is exposed to the air. It begins with the physical absorption of oxygen and is continued by the formation of a solid chemical compound of coal and oxygen, which is gradually decomposed as the temperature rises. Decomposition is not complete, however, until the temperature reaches about 445 deg. F. This first stage of the process generates heat but not as much as the second stage. The coal increases in weight by the amount of oxygen retained.

Second Stage of Spontaneous Heating

Second stage involves the breaking up of the solid compound of coal with oxygen and the formation of the final oxidation products—carbon dioxide, carbon monoxide and water. With the Appalachian coals, this stage begins to be appreciable at about 85 deg. F. and increases in intensity as the temperature rises. With lower-rank coals the beginning temperature is lower. Both stages of the process go on simultaneously, therefore, from about 85 deg. to 445 deg. F. There is no sharp transition from one stage to the other; the curve showing the relation between duration of heating and temperature is continuous. Rate of heating increases logarithmically with the temperature; that is, no coal has as an inherent property a critical temperature at which there is a sharp transition from relatively slow to rapid heating. When the term "critical temperature" is used, it should be clearly defined as the temperature at which the rate of generation of heat becomes greater than its rate of dissipation under certain fixed conditions. For other conditions, this critical temperature will be different.

For example, in a storage pile overheating usually starts in fine coal at a point about 6 ft. from the surface. If combustion ultimately develops at this point, one may regard the temperature of the coal when placed in storage as its critical temperature in so far as critical temperature is determined by conditions that prevail at this particular point. At any other point where conditions (fineness of coal, rate of air supply, and the like) are different, the critical temperature will be higher.

Pyrite, when finely divided, can increase the tendency of a coal to heat spontaneously. Although it has been shown that coals containing virtually no pyrite have fires spontaneously, it has also been quite definitely shown that fine pyrite when present in the coal does increase the rate of oxidation. One would not, therefore, select for storage a coal containing fine pyrite.

Effect of Moisture on Heating

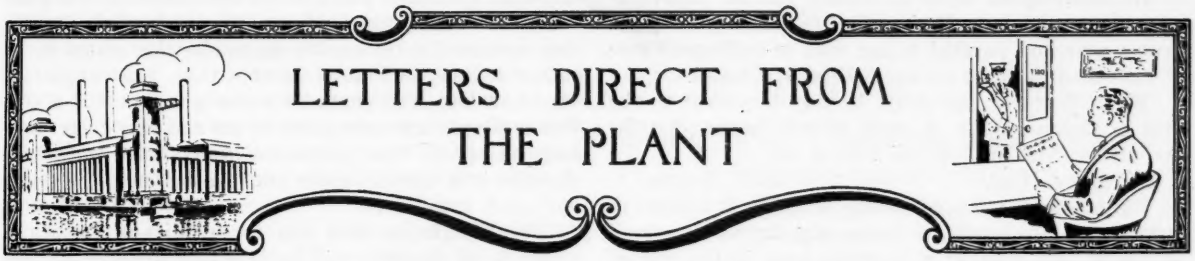
Opinions differ as to what effect moisture in coal has on spontaneous heating. Probably the effect of moisture is determined by the conditions of storage. If one could be sure of wetting only those parts of the storage pile where spontaneous heating would otherwise develop, he could probably prevent it; the heat required to vaporize the water would be more than the oxidizing coal could supply; however, wetting down the surface of the whole pile changes the conditions of ventilation and may favor heating at points not reached by the water, where dangerous heating would not otherwise occur.

Chemical factors other than those touched upon above have little or no influence on the spontaneous heating of coal. Laboratory studies have indicated what kinds of coal heat the most readily and their relative tendencies to heat can be measured by several methods. The effect of fine coal, pyrites, and so on has also been shown. The fact remains, however, that all bituminous coals have heated in storage when conditions were favorable. It is believed, therefore, that the most fruitful studies of the future will deal with storage conditions. Work is particularly needed on the effect of air supply.

Knowledge of Facts Helps to Stabilize Business

AS A HELP toward control of business, preventing booms as well as slumps, three factors have had major influence: the Committee on Business Cycles of the President's Conference on Unemployment, which spread a better understanding of the causes of business ups and downs; publication of a weekly and monthly Survey of Business by the Department of Commerce, giving statistics of 1500 indicators of the condition and trend of business; efforts of government to insure that statistics be honestly collected and used to inform and enlighten the business public instead of to flimflam it.

"It is too early to be sure that these factors have actually done away with booms and slumps, as it is scarcely six years since the last depression, but for five years there has been generally sustained prosperity without violent fluctuations and the experience is reassuring." This is the comment of Mortimer B. Lane, editor of the Survey of Business, which seems to justify Secretary Hoover's comment in 1925 that, "Stability or instability in production and distribution is largely the result of the collective judgment of the trades. They can form a right judgment only as they know the facts as to their own business and the probable trend of business in general."



Common Interest Should Exist in Power Plants

COMMON INTEREST in power plant work is something to be given serious thought. In my opinion, an engineer,—in fact, the entire power plant force—should think of the company interest directly as their own and the management should think of the power plant force in a like manner; for how can a high point of efficiency be reached or maintained without 100 per cent coöperation? That coöperation cannot be effected without mutual interest. The management cannot expect the power plant force to have any interest in the company or their work if no reciprocal interest is shown. When the company buys new machinery, it is with a view to larger dividends. If a power plant employe does his work with the interest of the company in view, he is making his employment a paying investment to his employers and the more interest he takes in his work, the more likely will his employment pay and the more the company can and usually does return to him in wages.

The employe who cannot have the interest of his company at heart should not be retained long. I have known cases where an employe, when put on a repair job, said, "If I can't fix it, I'll fix it so nobody else can." To my mind, that kind of a workman has no interest in himself, his job, nor the company that is supplying a livelihood for him and his family. If a power plant employe will look after the company's interest, he won't need to worry about his own, as the company will usually take care of that. If it does not, he should promptly change his job.

Louisville, Ky. FRED E. BOND.

Fuel Heaters Raise Diesel Engine Efficiency

PERFORMANCE of any heavy oil engine may be improved by heating the oil before supplying it to the fuel valves. The efficiency of an airless injection engine is dependent on the temperature of the oil, as well as on the nozzle temperature, the efficiency of the atomization varying with the viscosity of the oil which is reduced as the temperature rises. An engine employing air injection will benefit to a lesser degree.

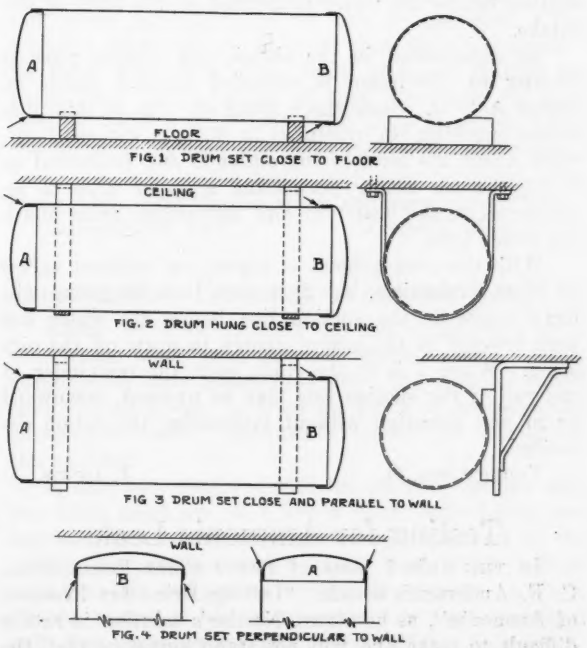
Heat from exhaust gases can be used to supply heat to the oil heater. This will increase the thermal efficiency of the engine, as the higher the temperature of the oil entering the cylinder the more complete is the combustion, while the heat which the fuel absorbs from the exhaust gases is returned to the cylinder. After the oil has been warmed, it may be passed through an oil filter, thus insuring a clean oil supply for the injection valves and reducing the risk of these valves becoming choked.

Although a proper oil heater may soon be developed which can be attached to the exhaust manifold, a moderate heating of the fuel can be secured by running the fuel supply piping for a short distance in close proximity to the exhaust piping. The two pipes must not be in actual contact on account of the fire risk and also that due to difference of expansion and contraction of the two pipes when heated. By suitably arranging the run of the piping, the temperature of the oil may easily be raised to 100 deg. F., which will show a marked improvement. The only difference between the usual Diesel oil and boiler oil is that of viscosity. By the use of oil heaters, it would be possible to reduce the viscosity with equally satisfactory results and so use less expensive boiler oil instead of the more expensive Diesel oil.

Brentford, England. W. E. WARNER.

Bumped Heads and Drum Location

LOCATION of pressure drums largely determines the type of bumped heads to be used because, in case of leakage, it is generally important to be able to calk the leak without moving the drum.



BUMPED HEAD WHICH FITS INSIDE OF SHELL USUALLY CAN BE CALKED IN PLACE WITH EASE

In this respect, style A usually has an important advantage over style B since it is customary to place drums near and parallel to the wall or ceiling. Three of such conditions are shown in Figs. 1, 2 and 3.

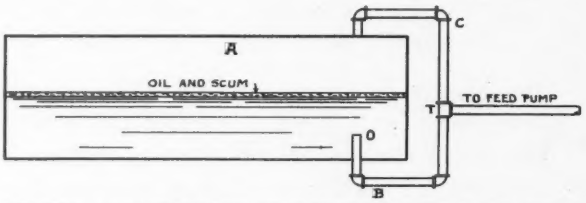
When, however, the drum is placed vertical to the wall as shown in Fig. 4, style B will be found to be the most convenient bumped head to use.

Waverley, Mass. IRA R. YOUNG.

Editor's Note: An advantage of Style B is that, in large drums, the heads are frequently shrunk-on as well as riveted. It is easier to heat the head in the case of Style B than to heat the end of the drum, as would be necessary in the case of Style A. Moreover there is much greater likelihood of unequal heating in the case of A than in the case of B.

Heater Connection Prevents Draining Off Scum

WHEN WATER is drawn from an open heater or tank there is always a chance that some time the supply will be interrupted or insufficient, so that the water level in the tank is lowered and the oily scum often found on the surface will be drawn off by the pump and fed into the boilers. To insure against this, the piping should be arranged as shown in the illustration, with a connection to the tank above the water



PROPER ARRANGEMENT OF PIPING PREVENTS OIL FROM BEING DRAWN OFF BY FEED PUMP

level, so that the pump will take steam or air into the suction before the water is lowered to the level of the intake.

As represented in the sketch, the suction pipe B leading to the pump is extended upward inside of heater A to O. Somewhere along the run of this pipe before reaching the pump as at T, it is extended upward above the level of the outlet O and connected as at C, the tee fitting permitting a vapor pipe to be connected to the heater at any convenient point above the water level.

With this arrangement of piping and without valves or other mechanism, it will be seen that the pump will draw vapor in the suction line before the water has been lowered in the heater enough to draw off the oily scum. When T is at the right level, the remainder of the run of the suction line may be upward, downward or in any direction without influencing the action described.

Youngstown, O. J. LEWIS.

Testing for Ammonia Leaks

IN THE July 1 issue of Power Plant Engineering, C. E. Anderson's article, "Testing Brine for Presence of Ammonia", as he states, Nessler's solution is rather difficult to make and will not stand aging, in fact, the solution is not used by many refrigerating engineers although, for many years, it has been considered a good test for ammonia. Referring to Mr. Anderson's absorption method for testing for ammonia, this seems to be rather tedious and more trouble than most engineers care to take. The engineer wants some sort of a test that is simple and convenient to use and easy to get and keep on hand. The writer has always used phenolphthalein; it is not expensive and can be bought at most any good drug store.

Phenolphthalein is a test for alkali and since ammonia is an alkali, it will indicate the presence of ammonia. It is true that it will indicate the presence of lime and some other alkalis, so, to use the chemical, one must use a little judgment. For instance, if one wanted to know whether a double-pipe ammonia condenser were leaking, the proper procedure would be to test the cooling water before it passed through the condensers and if it did not show pink with the phenolphthalein, test the water after passing through condensers. If this showed pink, it would be evidence that ammonia was leaking into the water.

This phenolphthalein test is so sensitive that the outgoing water from 20 or more stands can be tested and if there is the slightest amount of ammonia in the water, the pink shade will indicate it.

Many engineers use this test daily by dropping a small portion of phenolphthalein in 6 or 8 oz. of water from the outlet of their condenser batteries and if the test shows slight pink, they know that one or more of the stands are leaking. Testing samples of water from each stand soon localizes the leak.

This is a simple and effective test and one that will save considerable ammonia where two-pipe condensers are used. Compressor jacket water, water from ammonia liquor coolers and forecooler water can be checked from day to day by the engineer without much trouble or expense.

Brines also can be tested with the phenolphthalein test. Since the brines are usually slightly red, it requires a little more care than when testing water; in fact, it is a good plan to filter the brine before testing, however, it is not absolutely necessary. By using the same quantity of phenolphthalein and solution tested each time the test is made, the alkalinity of the solution can be watched from time to time and noticed as to increase or decrease in color.

When the test is made and a pink color appears, it does not mean that there is a serious leak, for the test is extremely sensitive and indicates the presence of the slightest amount of ammonia. A little use of the chemical soon clears up this feature.

It is suggested that the engineers reading this article go into some good drug store and get a couple of tablespoonfuls of phenolphthalein and half dozen 8-oz. bottles with corks, take them to their plants and try out this test. They might even do some "sleight of hand" work for the crew by turning water to wine and with a drop or so of acid, turn wine back to water.

The writer also uses phenolphthalein for testing distilled water for alkalinity when the ice is off color. Boiler compounds coming over with the steam make bad ice. Poor boiler feedwater will also concentrate in the boilers and come over with the steam, this being especially true when the boilers are overloaded. This raw water in the steam invariably makes white ice and

the test will locate the trouble. The remedy is to change boilers, reduce the amount of compound used or put more boiler capacity on the line.

A "pinch" of phenolphthalein half the size of a navy bean off a clean stick into eight ounces of the solution to be tested gives good results. The cork should be inserted in the bottle when in the presence of ammonia gas, as the water will absorb the ammonia and spoil the test.

This test is not along the ideas of the "high-brow chemist" but does answer the purpose of the engineer on the job.

Jacksonville, Fla. GAY A. ROBERTSON.

Wire Screen and Clippings Make Good Separator

EXCELLENT SEPARATION and straining were accomplished by means of the steam separator and strainer shown in sketches. A 2-in. steam separator is shown in Fig. 1, in which A represents two 4-in. plugs, each drilled and threaded for 2-in. pipe. I is a cylinder, open at each end, made of heavy brass wire screen and double seamed at K.

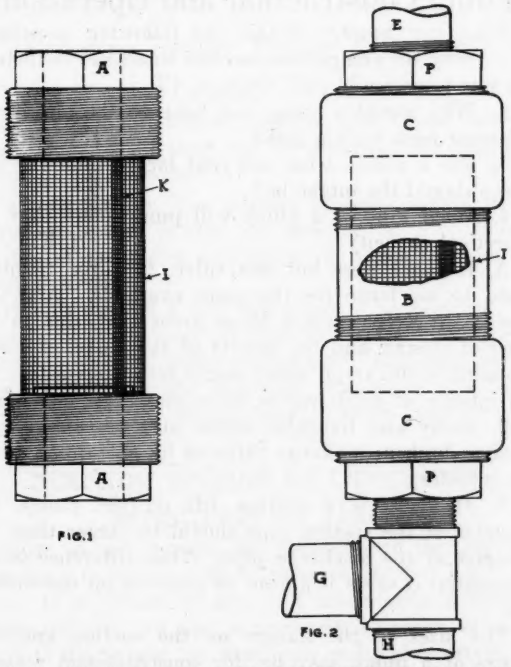


FIG. 1. WIRE SCREEN AND PIPE PLUGS FORM BODY
FIG. 2. ASSEMBLY VIEW SHOWING CONNECTIONS

Figure 2 is an assembly view, in which the 4-in. plugs are shown at P. C represents the 4-in. couplings and B is a 4-in. nipple. E is the steam inlet and G the outlet. H is connected to the sewer or other waste and contains a control valve as usual to enable the removal of the condensate.

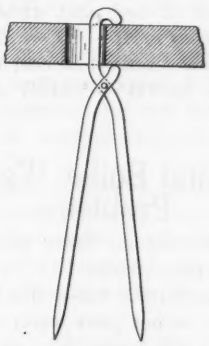
Cuttings of scrap wire gauze or screen, which have been loosely bunched up into ball shape, fill the screen cylinder and at its lower end a perforated or slotted cover is provided so as to prevent the dropping out of the bunched-up clippings. This cover is made of a piece of iron plate ⅛ in. thick. Thus passage of the steam is only slightly checked so as just to allow the water and oil to separate.

For a 2-in. separator, the writer prefers a 4-in. nipple about 6 or 8 in. in length and a 5-in. pipe and couplings.

Toronto, Canada. JOHN ELLETHORN.

Boiler Shell Thickness Measured with Home-made Calipers

WHEN IT IS necessary to determine the actual plate thickness of a used boiler, particularly an old one, there is only one exact way to do this and that is to drill a hole where thickness measurement is desired and then caliper the shell thickness with a "plate-gage" made for that purpose. The jaws of such a gage are slim enough to be inserted in a hole made for a ⅜-in. pipe tap. The gage-jaws are long enough to permit calipering far enough from the hole to avoid the burr raised by the drill.



CALIPERS MEASURE THICKNESS OF SHELL

Failing to have one of these gages, two little separate gage-legs may be made up of small square rod by bending it so as to bring the legs together in caliper form while one piece is in the hole. Hold or clamp the loose gage-legs securely together while they are so marked as to allow being placed together again in same position after removal from the hole in the shell. The separate gage-legs are so made that their "tail-ends" lie flush with each other when clamped against the plate, then the thickness of that plate may be read directly from a steel scale, the plate thickness being the distance between the two "tail-ends" of the gage-legs. The hole in the boiler shell may be closed after being tapped by means of an ordinary pipe "plug."

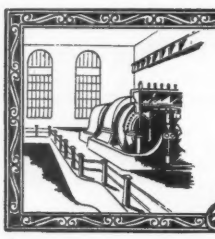
Indianapolis, Ind. JAMES F. HOBART.

Lubrication Reduces Wear on Packing

RAPID WEAR of packing in the stuffing-box of a centrifugal pump gave me considerable trouble. After running for only about four days, the packing would drop out in pieces. I tried all kinds of remedies unsuccessfully until I adopted a method of lubricating the packing.

It had been observed that the packing became very dry after short use, so I had a ⅜-in. hole drilled and tapped about ½ in. from the pump head end of the stuffing box and screwed a grease cup, which I filled with graphite and grease in equal proportions, in place. By this means, it has been necessary to pack the pump only five times during the past 2 yr.

Seymour, Conn. CHARLES MEHR.



QUESTIONS AND ANSWERS

Interchange of Heat in Cooling Water

WILL YOU PLEASE send me the formula for figuring the number of pounds of ice it would take to reduce the temperature of 2000 lb. of water from 90 to 75 deg. F.? M. C. C.

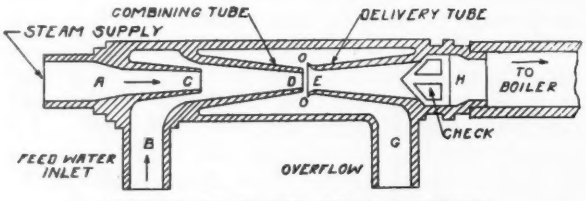
A. The loss in heat by the water would be $(90 - 75) \times 2000 = 30{,}000$ B.t.u., since the latent heat of ice is 143.5 B.t.u., which is the amount of heat required to melt 1 lb. of ice at 32 deg. and since the sensible heat given up by the water is $90 - 75 = 15$ B.t.u. The number of pounds of ice required to cool the water from 90 to 75 deg. will be $30{,}000 \div [143.5 + (75 - 32)] = 160.8$

Injector and Boiler Water Level Problems

WILL YOU please let me know why an injector will not put hot water into a boiler?

2. By reference to the tubes of a boiler, how would you know whether or not your water column was at the correct level? B. M.

A. Injectors will not pump hot water because hot water will not condense steam fast enough to create a



SECTION OF SINGLE TUBE INJECTOR

high enough velocity of the fluid to overcome the boiler pressure

To aid in understanding the operation, a diagram of the simplest form of a single tube injector is given herewith. Boiler steam, admitted at A, flowing through nozzle C and combining tube D to the atmosphere through G, partially exhausts the air from pipe B, thereby causing the water to rise until it comes in contact with the steam. The steam emerging from nozzle C at high velocity condenses on meeting the water and imparts considerable velocity to it. The energy in the rapidly moving mass is sufficient to carry it across opening O, lift check H from its seat and force it into the boiler. The steam then ceases to escape at G. Usually a check valve is provided in G which closes when the velocity of the water current causes a partial vacuum in the chamber around tubes D and E.

2. The water column of a boiler should be set at such a height that when water appears in the glass, it will be at such a height as to cover all parts that otherwise are likely to become overheated. Ordinarily that point in a horizontal tubular boiler is taken to be 2 in. above the upper row of tubes.

For standard type Stirling boilers, the A. S. M. E. code specifies that the column should be set in front of the middle drum, not less than 4 in. above the bottom of the drum and projecting through the sheet not less than 1 in.

For the superheating type Stirling, the code specifies the water column to be placed in the front drums, not less than 6 in. above the bottom of the drum exposed to the products of combustion and projecting through the sheet not less than 1 in.

Pump Construction and Operation

WILL YOU KINDLY explain the following questions:

1. Why do pumps have several small valves instead of a few large ones?

2. Why would a pump run lame on the out stroke and come back with a jerk?

3. For a pump, what per cent larger than the discharge should the intake be?

4. What kind of a pump will pump more than its theoretical capacity? H. K. C.

A. If there were but one valve, the area required would be too large for the space available. Also, the increase in weight would be so great that, due to the speed of closing and the inertia of the valve, excessive slamming would result which might result in rupture. A multiplicity of small valves overcomes these objections.

2. Jerky and irregular action may be caused by a stuck or broken discharge valve or by entrapped air in the cylinder.

3. If there is a suction lift on the pump, the diameter of the suction pipe should be larger than the diameter of the discharge pipe. This difference is not so essential if there is a head or pressure on the suction line.

The sizes of the flanges on the suction and discharge of a pump may be, for constructional reasons, smaller than that of the respective pipes, in which case, enlarging sections of pipe are installed close to the pump.

One large pump builder uses the following formulas for sizes of pipe:

$$D = \sqrt{0.1\ G}$$

and $$d = \sqrt{0.08\ G}$$

where D = diameter of suction pipe in inches
d = diameter of discharge pipe in inches
G = gallons per minute

For the suction pipe a velocity of 240 ft. per min. is allowed and for the discharge pipe the nominal allowance is 300 ft. per min. but this is often exceeded especially with centrifugal pumps.

4. No pump will pump more than its theoretical capacity if all conditions are properly taken into account. You probably refer to "rated" capacity. A centrifugal pump may be forced much above its rated capacity.

Boiler Bags and Patches

ANSWERS TO the following questions will be greatly appreciated:

1. If a bag occurs 3 or 4 in. from the girth seam of a boiler, what is the proper thing to do?

2. How should the furnace sheet of the water leg of a vertical boiler be patched? M. L. S.

A. If the bag is not deep and the sheet not otherwise damaged, the bag is generally removed by heating the sheet and straightening it. The girth seam in this case is reriveted at that section. If the bag has stretched the sheet and caused it to thin out too much or otherwise damaged it, a crescent-shaped patch is put on.

2. It has become general practice in recent years to electric weld a patch on the water leg of a vertical tubular boiler, where welding is permitted by law, because the stress is carried by the stay bolts.

Stirling Boiler Tubes Admitted Through Roof

IF A STIRLING boiler required new tubes, through what doors would they best be admitted for the first, second and rear banks? M. C.

A. Ordinarily if a number of tubes are to be replaced, it is best to take the covering off a portion of the top of the boiler and lower the tubes through the opening made.

If only one or a few tubes are to be replaced, the front bank can be reached through the top soot door in the front wall. For the second bank, take out the tile from the upper baffle and roof just above this baffle. For the rear bank, use the lower door in the rear wall.

Starting Engine by Operating Wristplate by Hand

HOW DO YOU HANDLE the wristplate in starting and stopping a double eccentric Corliss engine? I.M.C.

A. It is difficult to give full information without a demonstration. All that is necessary, however, in starting is to disconnect the wristplate rod which drives the wristplate that operates the steam valves and throw the wristplate by hand to the right or left according to the direction of running so as to admit steam into the cylinder, giving a much longer cutoff than would be obtained if the rod is hooked up. This is done on first one end of the cylinder and then on the other until the engine has speeded up enough to operate mechanically, when the rod should be snapped in place.

Stopping is accomplished in a similar way. The wristplate is operated by hand after the engine has slowed down considerably, the rod being unhooked and the wristplate operated by hand so as to admit just enough steam to bring the piston to the proper position for starting before the engine stops. The position of the crosshead indicates the position of the piston in the cylinder in any case. For easy starting, the piston should be at about ¼ to ½ stroke. This will give the flywheel sufficient momentum to carry the piston over dead center at which point steam is admitted to the other end of the cylinder.

Motor and Generator Performance

PLEASE INFORM me regarding the following:

1. Does change of voltage have any effect upon the speed of a motor?

2. How is the rheostat of a generator connected on the switchboard?

3. When you turn the rheostat regulating wheel from one position to another, increasing or decreasing the voltage, does this have any effect upon the flow of electricity? If so, what effect does it have?

4. Is the "live wire" positive or negative? M. C.

A. The speed of most motors, except synchronous motors which depend for their speed upon their frequency, is affected by the varying voltage. Increase in voltage results in increased speed but this increase is not directly proportional to the increase in voltage since the amount of increase depends upon the characteristics of the motor.

2. The field rheostat is connected in series with the field of the generator. The controlling wheel of the rheostat is frequently located on the switchboard and is mechanically connected through an actuating mechanism to the rheostat, which may be in any convenient location.

3. Increasing or decreasing the field current of a generator not operating in parallel with other generators will cause a corresponding increase or decrease of line voltage which, in turn, causes the machine to carry a greater or smaller load except in cases of tuned circuits.

4. If the negative is grounded, as is usually the case, the positive alone may be considered the "live wire."

Ports in Duplex Pumps

PLEASE LET ME know why a duplex steam pump has two ports at each end of the cylinder? M. L. S.

A. In order to prevent the steam pistons from striking the cylinder heads when the pump is operating at full speed, the double-ported or "five-ported cylinder", as it is sometimes called, has been adopted for simple steam ends of duplex pumps and for the low-pressure cylinder of compound steam ends. In this type of cylinder, the outside ports are for the admission of steam and the inside ports for the exhaust of the steam. The steam piston, as it approaches the head, covers the exhaust port and the remainder of the steam is trapped in the space between the piston and the head where it compresses and forms a cushion preventing the piston from striking the head.

Steam cylinders of 12 in. diameter and over are fitted with cushion valves in each end. These valves provide an adjustable steam cushion for the steam piston so as to insure a full stroke and at the same time prevent the piston from striking the cylinder head. The cushion valves are regulated from outside the steam cylinder by means of a hand-wheel attached to the valve stem.

EDITORIAL COMMENT

Law and Our Power Supply

During a recent technical society meeting, the statement was made that, with the gradually increasing efficiency of the central station and our diminishing fuel supply, the time would come when industrial plants would be restrained by law from making their own power.

This statement was immediately challenged and countered with the assertion that although legislation along this line might be enacted, the tendency would be to forbid certain industries, which use process steam, from purchasing electric power.

Fundamentally, the industrial power plant advocate is correct, as none of our present power generation methods taken alone can compare in efficiency or economy with power generated as a by-product of process steam. The problem of balancing the steam and power loads in a single plant is difficult and the idea of a limited utility is gaining ground rapidly. The era of combination industrial power plants where several industries operate a joint establishment to meet their combined electric power, steam and water demands is unquestionably under way.

Remarkable savings have been made by large industries abandoning several isolated power plants in different departments of their plant and serving all departments from an efficiently operated central plant. Except for an equitable division of construction and operating costs between the different owners, the operation of a joint plant between several non-competitive industries offers no more difficulties than a combination of departments under a single system.

Undoubtedly, obstacles will be encountered and the trials and tribulations of the pioneers will be great. It is, however, being hailed as the beginning of a new industrial era and in manufacturing communities should give the industrial plant new life.

Heating and Ventilating in 1978

Commenting upon a prediction regarding living conditions in 1978, The Aerologist points out that the prophet gave no intimation of the type of heating and ventilating equipment that will be used. Without doubt, The Aerologist says, it will be some sort of a combined system that will cool in summer and heat in winter.

This prophecy seems to us entirely sound, in view of the development that is now going on. Several large office buildings and hotels that we have seen are equipped with such combined systems; theaters, auditoriums and the like are installing them. Experimental work is now being carried on, we understand, to develop combination equipment for domestic use. For industrial use, a unit heater to take either steam or refrigerated brine is now on the market, together with several types of unit air conditioners. In short, rapid developments are being made in applying manufactured weather to the welfare of human beings just as it has been applied in industrial processes.

As recently pointed out in these columns, this is not a scientific age, regardless of what people think. If it were, would the human race be satisfied to spend millions of dollars to secure proper air conditions for making candy or matches and comparatively little to secure proper air conditions for itself?

But there are signs of an awakening. Of course, some scientific discovery may change entirely the development of the particular type of apparatus that will be used. But it is pretty safe to assume that by 1978, whatever the methods employed, the human race will have progressed far enough to live in such a way that the air in its habitations will be kept at the proper conditions of temperature and humidity regardless of outside temperature by a simple, inexpensive and entirely automatic device.

Interest Growing in Landscape Lighting

Perhaps the time is not ripe for the owners of all residences to make use of artificial illumination to beautify the exteriors of their buildings and the surrounding lawns and gardens. More than likely the custom will never become general but the possibilities of enhancing the beauty of an attractive residence and extending the enjoyment of the scene over more hours of the day by the use of well selected and properly located flood and spot lights are becoming known in some sections of the country.

Notable among these is the fashionable North Shore of Massachusetts where the modern art of illumination engineering has literally painted the bushes, shrubbery and lawns with light rays to give a most pleasing effect. Illumination after sunset may take on the effect of broad daylight, dawn, sunset or moonlight as the fancy at the moment may desire and spring or autumn tints may be given to bushes at will.

Those interested in the sale of electricity would, naturally, take the first steps in educating their communities in the art of landscape lighting. The utility's properties should, of course, be an example which others could follow. Sections of public parks could, in many cases, be used to display the art. Model residences in real estate subdivisions are being used to give an incentive to others in the community to use the art of illumination in beautifying their homes and surroundings.

In nearly every electric-lighted home, the housewife makes use of her artistic sense of color schemes and arrangements to make the home more attractive and

comfortable; many of them would welcome ideas on "stage lighting" their lawns and flower gardens.

Elevator Care

For elevators, as for all other machinery, "an ounce of prevention is worth a pound of cure." Minor freak operating conditions, if given proper attention and common sense analysis of cause and effect, can usually be easily remedied but, neglected, may become the start for major accidents to life and property.

In the series of article by Mr. Samuels, concluded in this issue, he has pointed out the locality of most frequent disarrangement and shown that, as in all remote control systems, difficulties can frequently be located in the electrical control circuits. There is nothing mysterious about an elevator but the service man, who sees an installation but a short time once a week or once a month, is not likely to observe slight irregularities of operation unless called to his attention by the operator.

Operators who are on the job all the time know these conditions and should report them so that each machine may have the specific attention that it needs as soon as possible. Thus a minor indisposition is prevented from developing into a serious illness.

Further, tampering with safety devices, especially the emergency release is serious and involves risk to operator as well as passengers. The very purpose of safeties is to avoid danger. If they are rendered inoperative or uncertain, danger is invited and more or less serious trouble will follow.

It is worth while to follow Mr. Samuels' suggestion that all controls be kept at all times in perfect operating condition and that safeties be kept safe. His articles will well repay careful study and attention.

The Engineer as a Farmer

Announcement that Thomas D. Campbell, president of the Campbell Farming Corp., was to be one of the speakers at the A. S. M. E. summer meeting in St. Paul last month has much more significance than may be apparent to the casual observer. For the operations of the Campbell Farming Corp. on 95,000 acres of land symbolize what seems to many the future of farming. The fact that the active head of this organization is himself a mechanical engineer, a member of the A. S. M. E., is indicative of an interlocking of engineering with agriculture that may change the whole trend of our civilization.

Farming in this country, if it is to make money for the farmer, will from now on probably have to be conducted as a business, not as a way of living. If a farmer chooses to regard it as a way of living the type of individualistic existence he so often desires, he must be willing to pay the price. On the other hand, if he applies the same principles to his work as the manufacturer does, it has been proved that he can attain a measure of financial success immeasurably greater than he could have in any other way.

For centuries, there has been a feeling that the life of the farmer, as such, was better than the life of the city man. It is not our function to pass judgment on that feeling. Entirely apart from that philosophical consideration stands the indisputable fact that this country is no longer an agricultural but an industrial country. In an agricultural society, the individual is paramount. But today we are tending toward a civilization in which the individual will count for little when balanced against the community, the industry or the race. Who can say whether this is a good or a bad tendency or whether it will continue to its logical conclusion? The farmer is confronted here with a condition, not a theory.

Now the great Campbell corporation is nothing more nor less than the result of the adaptation of business and engineering principles to agriculture. Mr. Campbell's success in this field, so long considered the domain of the farmer, to be apprehended only by some inborn, mystical process of divination, is an interesting commentary on the influence of the engineer.

It is not simply the fact that he has developed a large organization that has led to its success. A proportionate amount of financial success has come to individual farmers who have applied these business and engineering principles to their smaller units. It is not a matter of costly equipment and machinery. It is rather a matter of applying engineering analysis to the problems of farming. Such analysis may call for one crop or a diversified crop; it may call for soil analysis and crop rotation; it may call for live-stock or poultry or for their omission. In any case, it calls for application of engineering to the farm in the same way that engineering is applied to the making of automobiles, fountain pens and buttons.

Changes in every feature of modern industry must of necessity affect agriculture. Every tendency of modern industry is toward complex organization, large scale production, applications of engineering—with the object of large profits. If the farmer must have large profits, he can get them, if he is willing to abandon his individualism and to employ the engineering technique that has made other industries what they are today. Mr. Campbell has shown that it can be done.

Making Mistakes and Other Things

John Hays Hammond began his career as a mining engineer and gained fame in that profession before becoming prominent in finance and public affairs. Soon after graduating at the School of Mines in Freiberg, Saxony, he secured his first job with George Hearst, owner of one of the largest gold mining properties in California. Mr. Hearst took a great interest in the young engineer and later released him so that he could accept a position with the U. S. Geological Survey.

Several years later, the two met again in New York. Mr. Hearst asked Mr. Hammond how he was getting along. The latter replied, as told in a recent magazine article, that he was doing quite well, that he had as yet made no mistakes.

"But have you made any successes?" queried Mr. Hearst. "If you accumulate a few successes, you can make mistakes and be forgiven them."

Mr. Hammond does not tell what his reply was, if he made one. But Mr. Hearst made a shrewd comment on human nature and only the most unobserving will deny its truth. For, after all, whether we like it or not, life is essentially a contest, a struggle, a competition, in which the man who wins receives the approbation of his fellows, regardless of the fact that he may make some serious mistakes in the process.

POWER PLANT ENGINEERING DEVELOPMENTS AND NEWS

Compact Oil Circuit Breaker

COMBINING relatively high interrupting capacity and comparatively small overall dimensions, a new oil circuit breaker known as the type D-127 has been placed on the market by the Condit Electrical Mfg. Corporation.

An exceptionally heavy and rugged frame construction is used throughout and double tanks are furnished, supported by heavily ribbed cradle which is in turn hung by strong bolt construction with resilient features.

TYPE D-127 CONDIT OIL CIRCUIT BREAKER

The purpose of this type of construction is to absorb the mechanical shock incident to interrupting a heavy short circuit and to reduce to a minimum the hazard which usually follows the throwing of hot oil and gases emitted on heavy short circuits.

Main current carrying contacts are Condit inverted laminated brushes of special design which will withstand extremely high inrush currents. Exceptionally heavy arcing contacts are used whose large thermal absorption capacity materially reduces arcing on interruption. Until the brushes have safely parted, the arcing contacts remain firmly closed.

These circuit breakers are built in single units for 400, 600, 800 and 1200 amp. at 15,000 v., 1600 amp., 7500 v., and can be furnished for single pole or multiple operation; estimated interrupting capacity, 8000 amp. at 7500 v.

Owing to the small space requirements of the type D-127 oil circuit breakers, they are particularly adapted for replacing present breakers inadequate to meet the interrupting requirements of a station where large breakers could not be installed without considerable change in cell construction.

Dixon Announces New Product

JOSEPH DIXON Crucible Co., Jersey City, N. J., has announced a new addition to its line of graphite products. The new product is Graphite Seal—a graphite paste for sealing screw thread, flange and gasket joints of pipe lines carrying hot or cold oils, gasoline, etc. Being insoluble in oils and gasoline, this product will have many applications in oil fields and refineries, as well as extensive industrial uses on creosote, tar, vegetable and animal oil lines.

Dixon's Graphite Seal expands when subjected to heat and, it is claimed, makes leak-proof joints that hold tight under all conditions of service. Yet these joints may be opened with ease at any time without delay or damage to tools or fittings.

It is also recommended as excellent for use on handhole and manhole plates, or wherever there is a flange and gasket connection. Numerous other uses will be suggested. For automobiles, it is recommended in place of shellac for all gaskets and also for making joints in oil and gas lines.

Double-Pass Air Filter

TO PROVIDE an air filter of low cost which would retain the advantages of the Phoenix double-pass filter and yet be easily shipped and erected, the National Air Filter Co., Chicago, Ill., recently introduced its latest model—The Toopas. The filtering medium in this unit is of the endless curtain type, with small units of multiple layers of woven copper ribbon and expanded metal passing over large supporting wheels at the top and through an oil cleaning bath at the bottom. This arrangement presents two walls through which air must pass. The whole curtain is encased in a sheet metal frame, 28 in. wide, 18 in. deep, and in various heights.

Operation of the filter is simple: a few turns of the top roller each week. The motor drive can be eliminated without causing trouble, since a simple interlocking device enables one or many sections to be turned by one small handle.

Water Gage for 1500 lb.

SEVERAL NOTEWORTHY features distinguish the new water gage for working steam pressures of 1500 lb. developed by the Reliance Gauge Column Co., Cleveland, Ohio.

As shown by the illustration, this new water gage has staggered double visibility. A center controlled valve permits inspection of and work on the gage without shutting down the boiler. When repairs to one or the other of the sections have to be made, levels can be checked and controlled through the remaining section. If it happens to be the right one, an efficient water level is maintained by keeping level in glass a little higher than when both sections are in operation. Where the situation is reversed, and left section remains in operation, the water level in glass is kept lower than normal.

In designing this water gage the designers made the sections interchangeable, which means that a section,

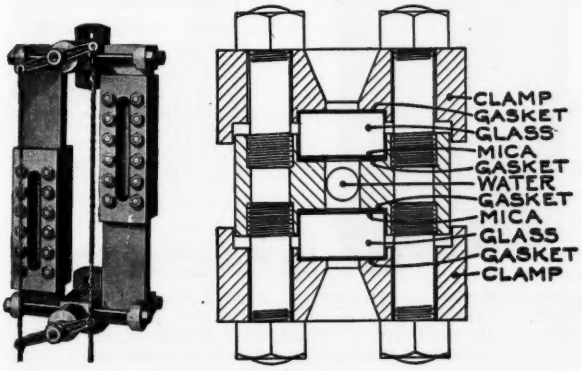


FIG. 1. RELIANCE GAGE COLUMN FOR 1500 LB. PRESSURE
FIG. 2. CROSS SECTION OF 1500-LB. GAGE COLUMN

instead of a complete gage need only be kept on hand for emergencies; even this is arbitrary, as previously explained, the boiler can be efficiently operated with only one section in place.

Contraction and expansion of metallic parts—steam and water in direct contact with glass—are two major factors that cause glass breaking. By looking at the sectional view it will be seen that mica plates protect the glass from direct contact with water and steam.

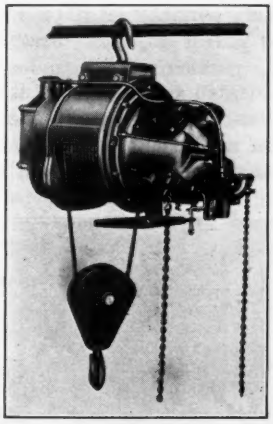
Air Mail Speeds Deliveries

EVEN BEFORE the recent reduction in air mail rates to 5c for the first ounce and 10c for each additional ounce, the saving in time was found well worth the added cost in a trial for over a month by Stephens-Adamson Mfg. Co. of Aurora, Ill., which has been using air mail exclusively between the main office and the Pacific Coast factory at Los Angeles.

C. H. Adamson, Secretary of the firm, reports that he can now mail a letter Monday afternoon and depends on having his reply with required blue prints, data, and specifications on his desk Friday morning. By regular first class mail, he considered himself fortunate to receive the answer by the succeeding Tuesday or Wednesday. Mr. Adamson says that in several cases his firm has been able to produce and ship an elevator or conveyor three or four days ahead of schedule and trace the saving in time directly to air mail.

Air Hoists Designed for Increased Speed

EMBODYING several new features, a line of CP air hoists is announced by Chicago Pneumatic Tool Co., 6 E. 44th St., New York. The three sizes now available have a capacity of 2000, 3000 and 4000 lb. respectively and have an enclosed type load block. The motor is four-cylinder, single acting. A balanced type control valve assures smooth and positive control. The

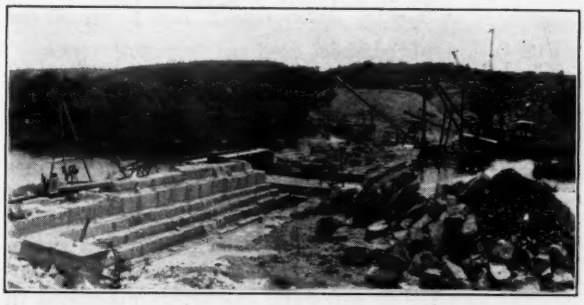


CP AIR HOIST WITH IMPROVED FEATURES

lifting speed has been considerably increased; for example, the 1-t. size will lift 2000 lb. at a speed of 40 ft. per minute. Other features include casehardened steel reduction gears, crank-shaft that runs on large size ball races, brake drum lined with Johns-Manville asbestos brake lining and Alemite lubrication. Special publication No. 1669, describing it, will be sent to those writing the manufacturers at the above address.

Texas Project Reports Progress

CONSTRUCTION WORK on the Devils River hydro development of the Central Power & Light Co., San Antonio, Texas, is progressing rapidly and at the last report was about 30 per cent completed. The dam,



GENERAL VIEW OF THE DAM LOOKING EAST

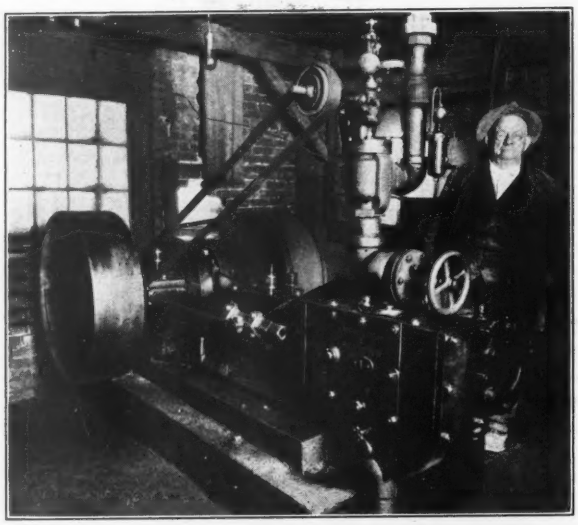
about 25 mi. from Del Rio, Texas, will be of rock masonry construction, 45 ft. high and 200 ft. long. One 2520-hp. S. Morgan Smith water wheel direct connected to an 1800-kw. Westinghouse generator will be installed.

Veteran Engine Found

RECENTLY the first engine built at Auburn, N. Y., in 1886 by John E. McIntosh and James A. Seymour of the firm which has since become the McIntosh & Seymour Corp., was discovered through an order for a minor repair part. For many years, the engine has been lost to the builders and an investigation showed that it had been through two fires, the latter of which bankrupted the first owner and left the plant a mass of ruins.

During the following year the engine was abandoned and exposed to the elements and the second owner accepted it to satisfy partially an unpaid note. After an overhauling, he put it to work in a lumber mill in Moravia, N. Y.

The engine is rated at 40 hp., runs at 300 r.p.m. and, in the second location, drove a circular saw from the belt shown on the right hand flywheel in the illustration. The mill was dismantled this year, but the old engine,



FORTY-ONE YEARS OF SERVICE IS THE RECORD OF THIS ENGINE

after 41 yr. of active service, was entirely satisfactory and considered by the owner well worthy of further use.

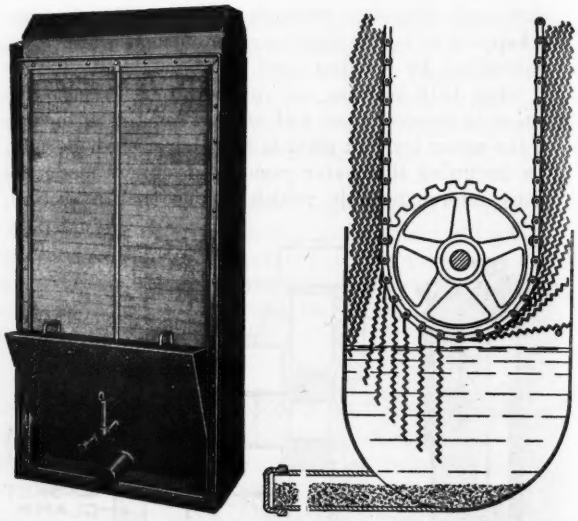
Out of sentiment the engine was bought back by McIntosh & Seymour Corp. and is to occupy an honored place in the present McIntosh & Seymour plant.

Self-Cleaning Air Filter for Engines and Compressors

AUTOMATIC AIR-FILTRATION for oil engines and air compressors is intended to be accomplished by the new Reed continuous filter, designed and built by the Reed Air Filter Co., Louisville, Ky., as shown herewith. Special attention has been given to reënforcing the filter to withstand the severe pulsations in this kind of service.

To neutralize the effect of air-pulsation and sudden changes of velocity, the filtering medium is mounted on heavy chains and is carried across the air passage between rigid angle-iron slides. The medium itself consists of a continuous curtain of double woven-wire panels overlapping six deep, like shingles on a roof. These panels are carried between ¼-in. rods extending the full width of the filter and spaced 1⅜ in. apart. Because the air is forced to pass twice through six double panels, 24 impingements are secured.

Just before reaching the cleaning tank at the bottom of the filter casing, the panels are automatically separated and are individually plunged down into and through the filter oil. The separation of the panels is



LEFT—FILTER IS DESIGNED FOR AUTOMATIC OPERATION. RIGHT—PANELS OF FILTERING MEDIUM SEPARATE FOR INDIVIDUAL CLEANING WHEN THEY ENTER OIL CLEANING TANK AT BOTTOM

intended to loosen the dust deposits, while the panels are arranged to strike and pass through the oil with force enough to wash them completely clean before they are automatically reassembled for the next circuit.

Unusually heavy construction and anti-friction bearings, together with the fact that the medium moves only ¾ in. every 12 min., are factors tending to minimize wear. The operating resistance is stated as only 0.35 in. of water. The filter unit itself is designed to be small and compact, to require little space and to be easy to install. Units are made for capacities of from 2800 c.f.m. to 20,000 c.f.m.

Furnace Temperature Measurement

OF TOTAL RADIATION type, the K & S Pocket Radiation Pyrometer has at the focus of the 1⅛-in. diam. collecting lens a bimetallic spiral 0.1 in. diameter and 0.001 in. thick. A pointer joined to the spiral moves over a transparent scale graduated in degrees for direct reading. A compensation spiral moves the scale to correct for room temperatures.

Through a red glass eye piece, condition of the furnace and reading on the scale may be observed at the same time, without correction for personal error.

Enclosed in a dust proof housing, the instrument is 2 in. diam., 6 in. long and weighs 6 oz. It is made by Colonial Supply Co., 217 Water St., Pittsburgh, Pa., in scale ranges from 1100 to 2600 deg. F. up to 1100—4000 deg. F.

News Notes

HIGH PRESSURE STEAM PLANT (120 atmospheres or 1764 lb. per sq. in.), constructed in accordance with the patents of Dr. Stephan Loffler, has lately been completed and put in operation at the works of the Wiener Locomotive Fabrik at Floridsdorf, Vienna, Austria. Great interest is being shown in the new plant, the inauguration of which was attended by many representatives of the Austrian Government.

ALFRED V. DE FOREST, research engineer for the American Chain Co., Chicago, Ill., was recently honored by the National Society for Testing Materials, which awarded him the Dudley National Medal for perfecting the non-destructive test for materials. Mr. de Forest has developed a device which performs such tests by magnetic analysis.

PRODUCTION OF ELECTRIC POWER by public utility power plants in the United States for May, 1928, as reported by the U. S. Geological Survey, reached a total of 7,121,015,000 kw-hr., an increase of 8 per cent over that of May, 1927.

TOTAL PRODUCTION of soft coal during the week ending June 30, including lignite and coal coked at the mines is estimated by the Bureau of Mines at 8,435,000 net tons. This is an increase of 0.5 per cent over the production for the preceding week. Total production of bituminous coal during the present calendar year to June 30 amounted to 234,280,000 net tons. Production of anthracite for the week ending June 30, including dredge and washery coal, is estimated at 1,122,000 net tons. Compared with the output in the preceding week, this is an increase of 3.6 per cent.

PREPARATIONS for an industrial survey of the state of New Hampshire, preliminary to a campaign to induce the location of new industries in the state have been started by the New England Power Association with the establishment of the New Hampshire Industrial Commission at Concord. Hugo Rocktachel of Worcester, Mass., has been appointed industrial director. This step by the New England Power Association is stated to be in furtherance of its plans to develop water power of Fifteen Mile Falls in the Connecticut River.

IDEAL COMMUTATOR DRESSER CO., Sycamore, Ill., announces that it now makes only one size of its solderless-tapeless wire connector and that this size will take care of all common joints in wiring practice. For larger wire it has placed on the market a connector that will take all combinations from four No. 14 to three No. 10.

ANHEUSER-BUSCH, INC., St. Louis Mo., has authorized plans for a new power plant at its brewing works to cost about $1,000,000. The new installation will include three 1100-hp. boilers with superheaters, to generate steam at 450 lb. pressure, 600 deg. total temperature. Power will be made by two turbine-generator units of 5000-kw. capacity each, designed for bleeding at 140 lb. pressure into a 30,000-lb. accumulator, with complete accessory equipment. Powdered coal will be the fuel. The average steam consumption of the processes is estimated at 170,000 lb. per hr., with a maximum of 260,000 lb. Ophuls & Hill, Inc., 112 W. 42nd St., New York, is engineer for the project.

THE ENGINEER CO., 17 Battery Place, New York City, has appointed Paul B. Huyette Co., 5 S. 18th St., Philadelphia, Pa., as its representative for Philadelphia, Baltimore and Washington.

MURRAY IRON WORKS CO., Burlington, Ia., announces the appointment of Wyman-Keagy Co., 1101 Chamber of Commerce, Columbus, Ohio, as district turbine sales manager.

THE NEW YORK EDISON CO. has just closed a contract for the installation in its East River generating station, New York City, of a 160,000-kw. turbine generator, which is now under construction by the General Electric Co. Steam generating units, which are to be installed by Combustion Engineering Corp., will have an aggregate heating surface of 45,120 sq. ft. each and the contract contains a guarantee that each of the four will produce 550,000 lb. of steam per hour. Engineering studies are being continued according to the New York Edison Co. officials, with the object of obtaining a maximum capacity of 800,000 lb. per hour each. It is stated that the total capacity of the condenser circulating pumps will be 1,400,000 gal. of water per minute.

LOCKWOOD GREENE ENGINEERS, INC., has purchased from Lockwood Greene & Co., Inc., the entire business of its engineering division, including its appraisal department. The new organization is a Massachusetts corporation formed by men who have been continuously associated with the engineering activities of Lockwood Greene & Co., Inc., for many years. The new company will maintain the present offices and will take over all contracts without change in its operating personnel.

ELECTRICAL CONTRACTORS, wholesalers, retailers and buyers and all engaged in distributing and supplying electrical appliances throughout the United States will have their own trade show in New York City at Grand Central Palace from October 17 to 19, according to a recent announcement. Arthur Williams, vice-president in charge of commercial relations of the New York Edison Co., is president of the exposition.

GENERAL REFRACTORIES CO. has recently developed, for service where resistance to dilute or concentrated acids is essential, a brick made from specially selected clay and burned to produce a dense body, which is being offered under the name "Acido". It is being made at several of the company's plants so as to take advantage of best freight rates.

ANNOUNCEMENT has been made by John J. O'Brien, president of Byllesby Engineering & Management Corp., 231 S. LaSalle St., Chicago, Ill., that Wm. J. Hagenah is joining the corporation as vice president and special counsel. Mr. Hagenah is a graduate of the University of Wisconsin, has held several important positions as statistician for public utilities and government bureaus and has made many appraisals and rate studies for municipalities and corporations.

MISSISSIPPI POWER & LIGHT CO., Jackson, Miss., is carrying out an extension and improvement program in various parts of the state. This includes building of various transmission lines and switching stations.

CLAUDE HARTFORD has been elected vice-president of the American Elevator and Machine Corp., with headquarters at 113-115 Cedar St., New York City, from

August 1, 1928. Mr. Hartford has been manager of the Industrial Relations department of the New York Steam Corporation, with which public utility he became associated in July, 1913, serving successively as assistant to the chief engineer, superintendent of the district embracing the lower portion of Manhattan, and engineer, Contract Department. Mr. Hartford received his engineering education at Stevens Institute of Technology and Cornell University being graduated from the latter institution in 1910 with the degree of Mechanical Engineer. He was elected a Member of the American Society of Mechanical Engineers in 1912.

THE ILLINOIS POWER and Light Company, owner of the Illinois Traction System, has purchased the Nertney building in Ottawa, Ill., and will transfer its offices now located in Joliet to Ottawa about September 1. The Ottawa building will become division headquarters for the power and light company as well as the traction system and traffic office will be established there also.

THE STORY CITY, Iowa, municipality has made contract with the Central States Electric Co. to sell its surplus power at the rate of 3c a kilowatt-hour. The contract calls for the measurement being made at the generating plant.

HEADQUARTERS of the Iowa Public Service Co. of Ft. Dodge, Iowa, which recently acquired the Sioux City Gas and Electric Co. from the United Gas Improvement Co., will soon be moved to Sioux City from Ft. Dodge and the two companies will be united under one office. The change will bring about 200 utilities employes from the Ft. Dodge office to Sioux City. Donald Stearns, president of the Iowa Public Service Co., who has been making arrangements for the transfer, is expected to make formal announcement of the plan soon.

Books and Catalogs

PROBABILITY AND ITS ENGINEERING USES, by Thornton C. Fry; first edition, cloth, size 6 by 9 in., 483 pages, illustrated. D. Van Nostrand Co., Inc., 8 Warren St., New York City, 1928; price, $7.50.

Here is a valuable source book covering the theory and principles of probability. It discusses their adaptability to present and future needs of various branches of industry, business and economics. Its pages afford a broad exposition and complete development of the use of probability as a tool of the economist, engineer, statistician, mathematician and scientist.

Dr. Fry apparently has spared no effort in making the book both broad and thorough enough to form a foundation for workers in all branches of industry and learning. He has used as his theoretical background his experience as a teacher of engineering mathematics at the University of Wisconsin and as his practical background his researches in the Bell Telephone laboratory and his contacts with problems and methods of the American Telephone and Telegraph Company and the Western Electric Co. In addition, the subject matter of the book has been used as the basis for a series of lectures given in the Electrical Engineering Department at the Massachusetts Institute of Technology. This text matter sets forth clearly and practically the manner in which the data and observation of pure science, the data of telephone, power and transportation and its statistical facts of commerce and finance are interpreted and evaluated and how these facts are used in meeting the needs of industry.

At the outset, the author establishes a concrete meaning for the term "Probability" in the reader's mind and develops at considerable length the fundamental mathematics of the subject. He then takes up its engineering uses, discussing a wide variety of distribution functions both theoretical and empirical and pointing out the uses to which they may be put. He has enlivened his subject by the inclusion of many interesting problems; the Question of Bertrand's "Box Paradox", the "Life of Mars Paradox" and the "St. Petersburg Paradox" and many other illustrative examples.

Throughout the book, in presenting his subject matter, the author supplements his mathematical reasoning by a presentation of the common-sense viewpoint so necessary in a work of this type.

SUPERHEAT ENGINEERING DATA, The Superheater Co., 17 E. 42nd St., New York; 248 pages, 104 illustrations; 4½ by 7 in., cloth, $1.

This is the seventh edition revised and is a particularly useful and practical treatment of the subject. Starting with properties of saturated and superheated steam, it shows the reasons for the use of superheat, also the gains in prime mover economy, pipe line performance and boiler operation.

Design of superheaters, arrangement in various types of boilers and requirements for piping systems are discussed, followed by tables of pipe and fittings and capacities of pipe lines. Complete tables of properties of saturated and superheated steam are given from 29.8 in. vacuum up to 3300 lb. pressure and 1005 deg. F.

Tables of engineering data, covering weights and measures, properties of metals, screw thread and wire tables and the like occupy 37 pages.

In the last 76 pages are illustrated and described the construction and arrangement of the company's superheaters for all types of vertical, horizontal and inclined tube boilers, for locomotives, for separate firing and of reheaters and desuperheaters.

The book is conveniently arranged, well printed and fully indexed.

MACHINES for heating rivets, employing both electrical heating elements and oil fuel heating and flue welding machines and furnaces are described in recent bulletins issued by Macleod Co., Station B, Cincinnati, Ohio.

AUTOMATIC arc-welding by the electronic tornado process is discussed by the Lincoln Electric Co., Cleveland, Ohio, in an illustrated 8-page bulletin.

MULTI-STAGE centrifugal pumps including high-pressure, boiler feed pumps are described in bulletin 212, issued by the Pennsylvania Pump & Compressor Co., Easton, Pa.

SOLVAY CALCIUM chloride for refrigeration is discussed in a recent bulletin isued by the Solvay Sales Corp., 40 Rector St., New York, N. Y.

DISCUSSION of factors that affect lubrication such as bearing metals, oil grooving and methods of lubrication is given in an interesting illustrated article on plain or sleeve type bearings in the June, 1928, issue of Lubrication, published by the Texas Co., New York City.

CHROME STEEL PUMPS for mine waters, in both centrifugal and triplex types, are described in bulletin 114 of the Hayton Pump & Blower Co., Appleton, Wis.

OXY-ACETYLENE equipment, its uses and applications are described in a 56-page booklet showing generators for production of acetylene, a new type of cutting blow pipe, welding apparatus and floodlights. This publication can be had on request from Oxweld Acetylene Co., Room 401, 30 East 42nd St., New York, N. Y.

COPES FEEDWATER REGULATORS is the title of a new booklet which describes in detail the construction of these devices, their principle and method of operation, recent improvements for service on high-pressure boilers and the results in control of feedwater level and plant performance by their use. Copies may be had by writing to Northern Equipment Co., Erie, Pa.

DETAILED DESCRIPTION of the Decalcomania process for reproduction is given in the latest edition of the Weather Vein issued by the Carrier Engineering Corp., 750 Frelinghuysen Ave., Newark, N. J.

"CATERPILLAR" power for factories, railroads, public utilities and mines and quarries is discussed in four recent bulletins showing applications of the Caterpillar tractor with various types of work. These are issued by Caterpillar Tractor Co., San Leandro, Calif.

ARC WELDING in G. E. factories and in industry is described and illustrated in recent bulletins No. DEA-423A and GEA-995 issued by the General Electric Co., Schenectady, N. Y.

IRONTON FIRE BRICK is described in several 4-page folders sent out by the Ironton Fire Brick Co., Ironton, Ohio.

COOLING DATA and information on Marley spray cooling equipment are given in a recent 24-page bulletin by Power Plant Equipment Co., 1737 Walnut St., Kansas City, Mo. It describes and illustrates in detail the various parts incorporated in Marley spray cooling equipment, such as spray nozzles and fittings, louvre posts and so on. It then gives tables and charts on water quantities and temperatures in connection with steam condensers, distribution of water from spray nozzles, tables of pipe friction, discussion of elimination of algae in spray ponds and much other useful information for the designer or operator of spray ponds.

IN THE July issue of The Safety Valve are given descriptions of boiler arrangements and certain types of furnaces for burning wood refuse fuel as used in lumber mills and industrial plants using wood working machinery. Copies may be obtained by request to Combustion Engineering Corp., 200 Madison Ave., New York, N. Y.

ELESCO SUPERHEATER for power plants is described and illustrated in Bulletin T-1, published by the Superheater Co., 17 East 42nd St., New York City. In the 51 pages are given the effects of superheated steam, advantages and details of the Elesco superheater, applications to various types of boilers, and reasons for superheat in turbine and pipe line practice. It is a handsome and interesting booklet, full of valuable information.

ENGINEERS FIRST—SALESMEN AFTERWARDS is the title of a 4-page bulletin recently issued by the Bakelite Corp., 247 Park Ave., New York City, discussing some of the products designed by the company's engineers.

ELIMINATION OF AN ASTHMA EPIDEMIC in the vicinity of a mill grinding castor beans is described in a 4-page bulletin, No. 95, by the Dust Recovering & Conveying Co., Harvard Ave. and E. 116th St., Cleveland, Ohio. The dust that caused this epidemic was eliminated by the Dracco System. Another bulletin, No. 518, describes how the Dracco system solves all lead oxide handling problems in a large battery plant.

HYDRAULIC TRANSMISSION OF POWER using accumulators and other hydraulic equipment is discussed in an article in The Hydraulic Press, No. 4, published by The Hydraulic Press Mfg. Co., Columbus, Ohio.

TORFOLEUM, an insulating material designed for ice and cold storage plants, sound deadening and general insulating purposes, is described in an illustrated booklet issued by Pennrich & Co., Inc., 29 Broadway, New York.

BUCKEYE DIESEL TYPE oil engines, 50 to 300 hp., are described and illustrated in a 28-page bulletin issued by Buckeye Machine Co., Lima, Ohio.

IN BULLETIN No. T-2, entitled What P & H Users Say, testimonials of users of its equipment are given by Harnischfeger Corp., Milwaukee, Wis.

INDUSTRIAL METERS for metering liquids are described by Badger Meter Mfg. Co., Milwaukee, Wis., in an 8-page illustrated booklet.

HELPFUL IDEAS FOR ENGINEERS from the original large Smooth-On Handbook are contained in a condensed edition of the handbook sent out by Smooth-On Mfg. Co., Jersey City, N. J.

WHAT ABOUT MERGER, an analysis based on a digest of typical opinions received from over 200 commercial and investment bankers, is the title of a 24-page bulletin recently issued by The Sherman Corp., 292 Madison Ave., New York, N. Y.

GETTING FACTS ABOUT ACCIDENTS is the second of a series of publications on industrial safety, a 34-page booklet just issued by the Policyholders Service Bureau of the Metropolitan Life Insurance Co., New York City.

USE OF CELITE IN CONCRETE is described in Folder 338 by Celite Products Co., 1320 S. Hope St., Los Angeles, Calif.

EVERDUR FITTINGS, valves and jets are described in bulletin 7-E by Schutte & Koerting Co., Philadelphia, Pa. In bulletin No. 5-H, the company describes and illustrates in color details and assembly of its multi-nozzle steam jet vacuum pumps.

ELLIOTT ENGINE TYPE A.C. GENERATORS are described in Bulletin I, a 4-page illustrated publication, by Elliott Co., Jeannette, Pa.

BROWN RESISTANCE THERMOMETERS of all types are described and illustrated in detail in an attractive and well-illustrated 54-page bulletin, No. 93, sent out by the Brown Instrument Co., Philadelphia, Pa.

USER EXPERIENCE, the key to future nickel steel applications, is discussed in a 16-page illustrated bulletin by International Nickel Co., Inc., 67 Wall St., New York City.

Power Plant Construction News

Ala., Mobile—Board of City Commissioners, Mobile, is said to be planning an early call for bids for equipment for extensions and improvements in the municipal waterworks, including 100,000-gal. capacity steel tank and tower in the Spring Hill district.

Ala., Mount Vernon—A. B. Jeffries, Citronelle, Ala., and associates are planning early construction of a local steam-operated electric power plant and system for commercial service. Permission has been granted by the Alabama Public Service Commission.

Ark., Eldorado—The Eldorado Laundry Co. plans installation of power equipment in connection with proposed rebuilding of portion of mechanical laundry plant, destroyed by fire July 27, with loss reported in excess of $100,000.

Ark., Norman—The Black Springs Lumber Co., Black Springs, Ark., is planning early construction of steam-operated electric power plant for local commercial service. A transmission line will be built for service in other districts, entire project reported to cost more than $85,000. A franchise has been granted.

Calif., San Francisco—The California Packing Corporation, 101 California street, San Francisco, plan installation of power equipment in connection with extensions and improvements in fish-canning plant at Fish Harbor to cost close to $100,000.

Calif., Sausalito—The Home Safety Match Co., care of Thomas A. Box, 63 Sunshine street (recently organized by Mr. Box and associates), is reported planning construction of one-story power house at proposed match factory in this vicinity. Entire project will cost more than $500,000.

Conn., Bridgeport—The Raybestos Co., Bridgeport, will install power equipment in a one-story addition to brake-lining manufacturing plant at Stratford, near Bridgeport, to cost in excess of $100,000.

Fla., Jacksonville—The Wilson & Toomer Fertilizer Co., West Bay Street, plans installation of power equipment in a proposed new addition to cost close to $90,000. Bayless W. Haynes is president.

Ga., Midville—The Midville Veneer Co. is reported planning construction of boiler house in connection with proposed rebuilding of its mill, recently destroyed by fire with loss estimated at close to $140,000.

Ill., Chicago—The Chicago Printed String Co., 2411 Clybourn Avenue, will install power equipment in its proposed new paper tape factory on Logan Boulevard, near Elston Avenue, entire project to cost more than $150,000. Alfred S. Alschuler, 53 West Jackson Boulevard, is architect.

Ill., Chicago—Mars, Inc., 718 Washington Avenue, North, Minneapolis, Minn., manufacturer of candy, will install power equipment, baking machinery, etc., in proposed one-story plant, 200x640 ft., at 2019-59 North Oak Park Avenue, Chicago, to cost $250,000.

Ill., Chicago—The Western Packing & Provision Co., 3830 South Morgan Street, will install power equipment in a new five-story plant addition to cost about $200,000. B. K. Gibson, 3830 South Morgan Street, is architect.

Iowa, Waterloo—The John Deere Tractor Co., Commercial and Miles Street, has filed plans for a proposed one-story power house at factory, to cost about $35,000, with equipment. Allan H. Head is vice-president and general manager.

Kan., Wichita—The City Service Gas Co., Wichita, has authorized extensions in gas compressor plants at Mooreland, Okla., Corwin, Kan., and Higgins, Tex., in connection with expansion in natural gas pipe line system, to include installation of new compressor units of 1,000 and 5,000 hp. capacity and auxiliary equipment.

Mass., Charlemont—The Charlemont Electric Light & Power Co. has secured permission to issue stock totaling $200,000, a portion of proceeds to be used for extensions and improvements in power plant and transmission system.

Mo., St. Louis—The Con-Ferro Paint & Varnish Co., 1168 South Main Street, will install power equipment in a new three-story plant to be built at 3200 Broadway, to cost about $100,000. Benjamin Shapiro, 4202 Holly Street, is architect.

N. C., Leaksville—The Moore Milling Co. plans installation of power equipment in connection with the proposed rebuilding of portion of its flour and grain mill, destroyed by fire July 26, with loss reported in excess of $75,000, including equipment.

N. C., New Bern—The Common Council is said to be planning the installation of pumping equipment and auxiliaries in connection with proposed extensions and improvements in the municipal waterworks. An expansion program is also proposed at the municipal electric lighting plant, including additional equipment.

N. C., Spring Hope—The Montgomery Lumber Co. is said to be planning the construction of a boiler house in connection with rebuilding of its mill recently destroyed by fire with loss approximating $100,000, including machinery.

N. J., Asbury Park—The City Council has begun the construction of a new municipal central steam power plant at the foot of Wesley Lake reported to cost more than $250,000 with equipment. Whitney Warren, 16 East Forty-seventh Street, New York, is architect.

N. J., Closter—The Rockland Electric Co. has secured permission to issue stock in amount of $400,000, a considerable portion of proceeds to be used for extensions and improvements in power plant and system, including transmission and distributing lines.

Ohio, Cambridge—The Akron Coal Co. is said to be planning the early rebuilding of portion of power plant, including boiler house, at its Goodyear mine, near Cambridge, recently destroyed by fire with loss approximating $30,000, including equipment. Clarence Long is superintendent.

Ohio, Orrville—Board of Public Affairs has awarded contracts for extension and reconstruction of the municipal plant boiler room structure, estimated cost $17,000. Burger Iron Co., Akron, will handle steel, and D. P. King received balance of the work on 72 ft. x 50 ft. building.

Ohio, Toledo—The Craig Oil Co., Columbia Bank Building, Pittsburgh, Pa., will install power equipment in connection with expansion and improvement program at its refining plant on Weaver Street, Toledo, entire project to cost more than $400,000.

Okla., Maud—The Common Council is considering installation of pumping equipment in connection with proposed extensions and improvements in the municipal waterworks, for which a bond issue of $45,000, has been approved. V. V. Long & Co., Colcord Building, Oklahoma City, Okla., are engineers.

Pa., Allentown—The Traylor Engineering & Mfg. Co., Allentown, will install power equipment in proposed new addition to its mining machinery manufacturing plant, entire project reported to cost more than $200,000.

Pa., Philadelphia—The American Ice Co., Broad and Cherry Streets, has plans for a new one-story and basement ice-manufacturing plant, 80x150 ft., on Summerdale Avenue, reported to cost in excess of $65,000, with equipment.

Pa., Pittsburgh—The Allegheny County Steam Heating Co., 435 Sixth Avenue, has begun the construction of a new steam power plant to cost about $650,000, with equipment, and proposes to complete the unit late in the fall.

Tenn., Cookeville—The Common Council has received authority by vote of citizens to issue bonds for $100,000, the proceeds to be used for extensions and improvements in the municipal hydroelectric power plant at Burgess Falls on the Falling River. Plans will soon be prepared.

Texas, San Benito—The Texas Citrus Fruit Growers' Exchange, San Benito, is reported planning construction of a boiler house in connection with proposed new local packing plant, entire project to cost close to $100,000.

Utah, Richfield—The Common Council is planning extensions and improvements in the municipal electric light and power plant, including installation of a Diesel engine unit and auxiliary equipment. Expansion will also be carried out for the municipal waterworks, including additional equipment.

Wis., Milwaukee—The Seaman Body Corporation, Richards Street, plans installation of power equipment in connection with proposed additions to automobile body manufacturing plant reported to cost more than $250,000. The company is a subsidiary of the Nash Motors Co., Kenosha, Wis.